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This TOP supersedes TOP 09-2-251, dated 18 August 1972.

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14. ABSTRACT
This TOP provides guidance for preparing test plans and conducting test programs to evaluate waterway equipment performance and operational characteristics and identifies required facilities and equipment. This TOP is applicable to barges; lighters; and passenger, cargo, landing, assault, picket, patrol, tug, tow, and special-purpose boats.

15. SUBJECT TERMS

Watertight Integrity	Operational Performance	Towing and Resistance
Static Flotation	Communications and Navigation Equipment	Beaching
Dynamic Pitch and Roll	Bollard Pull	Dock and Sea Trials

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 09-2-251A 25 September 2012
DTIC AD No.:

WATERWAY EQUIPMENT - BOAT, BARGE, MOTOR

*This TOP supersedes TOP 09-2-251, 18 August 1972

1. SCOPE.

a. This Test Operations Procedure (TOP) provides guidance for planning tests of waterway equipment, including harbor craft and floating equipment used in rivers, harbors, littoral waters, and amphibious coastal operations. Items covered include barges and lighters, boats (passenger, cargo, landing, assault, riverine and patrol, tug and tow, bridge erection boats (BEBs), and special purpose), landing craft and amphibians, outboard propelling units to include rigid hull and rigid hull inflatable boat (RHIB), and certain causeway systems configured as a Roll-on/Roll-off Discharge Facility (RRDF) or as a vessel to shore bridging assets. The test objective is to determine conformance of the test items with the Purchase Description (PD) or other suitability criteria.

b. The scope of testing will be selected from section 2 to satisfy the requirements for the particular test items and test type. For engineering tests, scope will be dependent on the criteria stated in the governing PD. For initial production tests, the scope will be in accordance with the contractual provisions of the applicable military specification and suitability criteria as established by the test plans. Procedures may require modification to suit special items.

c. The planning and executing of military operations, marine and amphibious in nature, requires a variety of waterway equipment for transporting personnel, equipment, and materiel over water barriers, ship-to-shore, through inland waterways, and within intact and degraded terminals, ports, and beach complexes to include purposeful port denial. Included are the following:

Small Craft	Portable assault, landing, and reconnaissance boats (rigid and inflatable) carry combat personnel in river crossing and calm water operations. Boats may be oar, jet drive, or outboard engine propelled.
Passenger and Cargo, Utility, and Picket Boats	Passenger and cargo boats and utility boats move limited amounts of cargo or small groups of personnel between ship and shore or between two shore points. They are self-propelled and are capable of moderate speeds.

	Riverine boats are used for command and inspection and for routine patrol missions in harbors and adjacent waters. They are capable of fairly high speeds and can make short trips to sea.
Harbor Tugs	Harbor tugs berth and unberth large ships and move barges, force protection barriers, and rapidly installed breakwater systems in harbors and adjacent waters. The predominant characteristics of harbor tugs are maneuverability, towing/pushing power, ample stability, and good cruising range. Limited firefighting equipment is provided on most harbor tugs.
Oceangoing Tugs	Oceangoing tugs are characterized by longer lengths, increased towing and rigging, and increased pulling capacity for operation in transoceanic crossings while towing barges and other vessels.
Cargo Vessels	Cargo vessels transport dry, liquid, and refrigerated cargo, personnel, and equipment. They have inboard machinery for propulsion of the vessel and are equipped with gear suitable for loading and discharging the cargo they are designed to carry. These vessels include high speed wave-piercing catamarans and beaching craft.
Non-propelled Barges, Conversion Kits, and Causeways	Non-propelled barges are of the dry, liquid, or refrigerated cargo type. Liquid or refrigerated cargo barges have installed machinery. Dry cargo barges may be of hold, deck, or enclosed-deck types and may be used as breasting barges, workboats, or cargo lighters. Conversion kits for certain deck barge designs convert these vessels to covered barges for the protection of cargo. Vessel to vessel interface causeway platforms allow ship to ship transfer of cargo at sea.
Landing Craft	Landing craft are designed to beach, unload or load on the beach, and retract. Loading or discharging landing craft at the beach is

	expedited by the use of bow ramps. Landing craft are used in tactical and logistical operations and for lighterage or utility work within harbors.
Amphibious Lighters	Amphibious lighters can traverse soft sand or rough terrain and can operate on hard, smooth surfaces at relatively high speed. The larger models have ramps similar to those of landing craft to expedite loading or discharge. Amphibious lighters are used to: Transport troops, equipment, and supplies from ships offshore to inland dumps and transfer points in tactical and logistical operations. Supply outposts located on nearby islands or points inaccessible by land from the principal supply points. Evacuate casualties and prisoners of war in retrograde movements. Transfer materiel from inland sites directly to ships.
Special Purpose Craft	Included are boats for special tasks such as bridge erection and pipeline laying; barges carrying specialized equipment such as for dredging or pile drivers, floating repair shops, or elevating piers; and floating cranes for heavy lifts, minesweeping, and salvage work. Barges may be sectionalized or nesting types.
Propelling Units	Separate propulsion units for boats and barges include conventional gasoline outboard engines and large diesel-engine-driven units for barge operation. Experimental craft may employ air propellers or waterjet propulsion. Warping tugs readily connect to corresponding causeway sections for maximum control and maneuverability
Vessel to Shore Bridging	Flotation equipment (powered and unpowered) that is used to connect shallow draft (non-beaching) vessels with the shore.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

a. Facilities for the testing of waterway equipment may be relatively simple or extensive, depending on the item to be tested. Inflatable rafts and boats may be tested in indoor or outdoor pools/wave ponds. Most boats and craft require navigable waterways, including rivers, lakes, bays, or coastal waters. Streams may be adequate for tests of small portable boats. Amphibians and landing craft require beaches and land tracts adjacent to waterways. For larger vessels, substantial piers, docking, and harbor facilities are required. Supporting watercraft, as well as marine servicing and maintenance facilities, is required for sustained tests.

b. Tests are arranged so that adequate facilities for the scope of testing are economically practical. This includes the use of borrowed facilities when required, such as equipment with heavy lift capacity, other marine craft, marine railway, cargo handling equipment, ballast weights, and high capacity bollards or other such anchorage points for propulsion thrust testing.

c. In selecting facilities, the need for (or freedom from) certain factors must be considered; for instance, open waters, wind, current, tide, surf, depth, obstacle, particular water bottom type and gradients, access, turbidity/salinity, and certain shore configuration. On navigable waterways, channel width and depth must be considered as well as marking, lighting, bridging and obstructions, quarantine areas, traffic lanes, and frequency of traffic. Provisions for personnel safety, including provisions related to the weather, should be considered in all cases. Aberdeen Proving Ground (APG) has facilities for small boats and access to various rivers, shallow water basins, and estuaries ranging in size from small coastal inlets to the Chesapeake Bay. Specific APG watercraft test facilities include:

(1) Underwater Explosive Test (UNDEX) Test Facility: This elliptical body of water measures 1070 feet by 920 feet with a depth of 150 feet. It is completely isolated from the Chesapeake Bay, making it an environmentally friendly test site. Watercraft access is via multiple 250-ton cranes or a 2200-ton capacity marine railway. There is a barge slip for delivery of test items directly from the Chesapeake Bay. The facility can accommodate explosive charges up to a maximum of 4100 pounds trinitrotoluene (TNT) equivalent.

(2) Briar Point UNDEX Facility: This 330-foot diameter circular body of water is isolated from the Chesapeake Bay. It has a 70-foot diameter circular bottom at a depth of 55 feet. Watercraft access is via a 15-foot seawall or 200-ton capacity marine railway. The facility can accommodate explosive charges up to a maximum of 200 pounds TNT equivalent.

(3) Littoral Warfare Environment (LWE): This facility has a 300- by 400-foot water surface with a maximum depth of 40 feet. It contains a 300- by 100- by 20-foot deep wave channel equipped with a computer controlled wave generator. Regular and irregular waves up to sea-state three can be produced with 1-6 foot significant wave heights from and 2-7 sec significant wave periods. The 350- by 150-foot beach can be reconfigured for multiple uses, including installation of obstacles. Firing of small arms from water to shore or explosive charges up to 500 pounds TNT can be accommodated.

(4) Stillwater Amphibious Area: This 30 acre, shallow basin test area provides a low current, low wave test area for calm water testing of shallow draft vessels. This test area is located within the confines of APG and in restricted waterways not accessible by the public.

d. Reciprocal agreements with Army and Navy organizations to support a variety of watercraft test support include:

(1) Fort Story, Virginia: Various facilities are available in the Hampton Roads area, Virginia, including ocean beaches, soft sand shorelines, and sea states of at least SS3.

(2) The Third Port Terminal Facility at Joint Base Langley-Eustis, Virginia, with various marine support craft, railway, shops, ship and pier cranes, including dock facilities for oceangoing vessels.

(3) Naval Station Little Creek Amphibious Base and Naval Station in Norfolk, Virginia: Primary watercraft test support consists of pier and deepwater dockage.

e. Facility requirements available at the facilities above include but are not limited to the following items:

Item	Requirement
Material-handling equipment (MHE)	Offload and load test item from transportation asset. Maneuver test loads and mooring equipment.
Maintenance shop	Accomplish Technical Manual (TM) receipt inspection, servicing, inventories, scheduled and unscheduled maintenance, and chamber test preparation.
Boom-type crane of suitable load capacity	Means to emplace Incline Experiment test loads during stability testing.
Bollard or pull force deadman	Anchorage point during Bollard Pull tests for propulsion system performance testing.
Block weights	To induce the required vessel reaction during Incline Experiment stability testing.
Quick-release hook	To conduct righting moment measurements.
Fording Basin	To conduct water-based incline experiments (stability).

Item	Requirement
Climatic chambers	Satisfy the requirements of Military Standard (MIL-STD)-810G.[1]**
Sand and Dust Facility	Satisfy the requirements of MIL-STD-810G or a suitable field testing environment.
Rain Test Facility	Satisfy the requirements of MIL-STD-810G or a suitable field testing environment.
Automotive road courses	Accomplish road transport durability and reliability road missions.
Gantry-type crane of suitable load capacity	Means to lift the system for drop and lift and tie-down provision testing.
Electromagnetic Interference Test Facility (EMITF)	Satisfy the requirements of MIL-STD-461F.[2]
High-Altitude Electromagnetic Pulse (HEMP) Test Facility	Satisfy the requirements of MIL-STD-461F.
Rail Impact Test Facility	Satisfy the requirements of MIL-STD-810G.
Cargo helicopter and approved flight path	Satisfy the requirements of MIL-STD-913A.[3]
Noise Test Facility	Satisfy the requirements of TOP 01-2-610.[4]
Fixed wing aircraft for test loading	Satisfy the requirements of Military Handbook (MIL-HDBK)-1791.[5]

2.2 Instrumentation.

The ability to measure vessel characteristics and record the results of testing is critical to the evaluation process. Requirements for transducers and/or physical measuring devices include. but are not limited to the following:

Devices for Measuring	Permissible Measurement Uncertainty
Weight	± 1% of reading
Physical dimensions	± 1 centimeter (cm) (± 0.4 inch (in.))
Inclination	± 0.25% reading

**Superscript numbers correspond to those in Appendix E, References.

Devices for Measuring	Permissible Measurement Uncertainty
Pull force	± 2% of reading
Wave height	± 5 cm (± 2 in.)
Water current	± 2% of reading
Wind speed	± 1 knot (kt)
Distance (over water)	± 0.1 kilometer (km) (± 0.1 mile (mi))
Speed (over water)	± 0.1 kilometer per hour (km/hr) (± 0.1 mile per hour (mph))
Speed (over ground)	± 0.1 km/hr (± 0.1 mph)
Ambient or chamber temperature	± 2 °Celsius (C) (± 3.6 °Fahrenheit (F))
Relative humidity (RH)	± 1% of reading
Surface temperature	± 2 °C (± 3.6 °F)
Total irradiance	± 4% of reading

3. REQUIRED TEST CONDITIONS.

3.1 Planning.

a. Safety. The Safety Assessment Report (SAR) prepared by the manufacturer, as typically delineated in the scope of work or request for proposal contracting documents, with the concurrence of the Materiel Developer (MATDEV), TMs, and other training material issued with the test item by the developer and manufacturer will be reviewed. Test reports for previous tests conducted on the test item, or similar equipment, will also be reviewed. The resultant assessment will support the generation of a Risk Assessment (RA) that delineates the known and potential hazards with their corresponding mitigation techniques and residual risk.

b. Requirements. The capabilities documents (e.g., Initial Capabilities Document (ICD), Capabilities Development Document (CDD), Capabilities Production Document (CPD), or Performance Specification (PS)) will be reviewed. For acquisition evaluated programs, the System Evaluation Plan (SEP) is the governing document. The SEP will document the methodology and data requirements. For non-acquisition projects, the customer test requirements will be followed based on information provided in the Request for Test Services (RFTS), Statement of Work (SOW), contract documents, and direct communication with the customer. Refer to the Department of the Army (DA) Pamphlet (PAM) 73-1[6], Chapter 4, for additional test planning and Army Acquisition information.

c. Facilities Selection. Test preparations include the selection of appropriate test facilities, arrangement for support, review of the safety statement from the developer, and selection and training of the test team, which may involve attendance at new equipment training (NET) courses. Adequate lead time should be planned to address the extensive support and training required for some pre-test, logistical considerations.

d. Team Members. Team members are desired to possess the requisite mariner skillsets associated with basic seamanship, nomenclature, boat handling, be accomplished swimmers, and be resistant to motion sickness. For vessels requiring crew licensing in accordance with regulatory requirements, valid certification will be ensured. The Test Officer will make available copies of pertinent publications and certifications as required. The test team will conduct practice drills and trials as necessary to ensure crew proficiency. Tests that require personnel to transit ramps or other platforms over water will require personal flotation devices and may require rescue swimmer support during test execution. If military personnel are required, ensure a Test Schedule and Review Committee (TSARC) request is submitted within one year from the start of testing or as early as possible. The overarching objective is to attempt to be realistically representative of actual equipment employment.

3.2 Test Scheduling.

To provide an early indication of test item suitability, safety-related tests and inspections will be conducted first, followed by physical characteristic measurements to ensure the system configuration requirements are satisfied. Reliability testing will be initiated when the data collection database is established, the test crew is competent in accomplishing all operator- and field-level tasks, and the break-in periods are met and all systems are operating as intended. As a general rule, it is advisable to conduct the more benign testing first to prevent premature damage to the test item and failure to maximize the amount of data acquired.

3.3 Ancillary Requirements.

The complexity of the shipbuilding and integration of Governmental oversight can begin at several stages of the process. Standards exist for all commercial and military vessels across a broad spectrum of vessel types and uses. The end result is construction of vessels that are seaworthy, mitigate risks to the users, and protect the world's waterways. Two principal classification societies ensure all seagoing vessels follow the standards and best practices for manufacture: the American Bureau of Shipping (ABS) and Det Norske Veritas (DNV). Test agencies are advised to leverage the results of the testing accomplished under the auspices of the requisite classification society to the extent possible.

3.4 Conduct.

a. Scheduled and Unscheduled Maintenance. The test item(s) will be maintained in accordance with the TMs, if available. If maintenance procedures are not available, if the crew does not understand the procedure, or if the crew has difficulty accessing the equipment, the manufacturer will be contacted for further information or guidance.

b. Test Data. For acquisition evaluated programs, all test incidents, maintenance actions, hardware or software modifications, and emerging test results will be recorded in Test Incident Reports (TIRs) in the Repository Information and Test Analysis (RITA) system. Non-evaluated programs can use RITA, or the Test Officer can submit daily/weekly status reports via e-mail or as daily/weekly reports using the Versatile Information Systems Integrated On-Line (VISION) Digital Library System (VDLS).

c. For much of marine procurement, certification of design characteristics is required in accordance with ABS and various sections of the Code of Federal Regulations (CFR), or Department of Defense (DoD) standards as incorporated in procurement specifications. Construction, arrangement, stability, life-saving equipment (delineated in CFR 46 160.076[7]), controls, components, and systems are required to conform to safety of life at sea (SOLAS) requirements. Sanitation, rat-proofing, and portable water systems must conform to requirements of the US Public Health Service (PHS) as outlined in Publication Numbers 68[8] and 393.[9] In general, compliance is determined during construction and acceptance trials. Test personnel should observe and participate in the procedures for determining regulatory compliance when practical.

4. TEST PROCEDURES.

4.1 Initial Inspection and Operation.

4.1.1 Method.

a. Upon arrival, the test item will be visually inspected, pursuant to, and to the relative extent of, the tenets of TOP 02-2-505[10] and the Maritime Safety Manual, Volume II[11] to identify any obvious defects in workmanship, construction, or damage as the result of shipping. All applicable protective materials will be removed, and any damage to, or deterioration, of the test item resulting from handling, improper packaging, or inadequate preservation will be recorded and photographed. An initial safety inspection will be conducted to identify potential hazards.

b. The system components, basic issue items (BII), and Test Support Package (TSP) will be inventoried. The inventory will be compared with the packing list or the TM, and all shortages will be identified to the manufacturer and system developer for resolution. The major component serial numbers (SN) and service life (operating time or distance) will be recorded.

c. If more than one test item is provided for testing, the test items will be assigned a test item identification number (TIIN) for identification and tracking purposes. The serial and model numbers of each test item and major component and operating hours of each test item, if applicable, will be recorded.

d. The test item will be set up in the operational configuration, and if required, an initial service (fuel and lubricate the system) will be performed in accordance with the TM or manufacturer's specifications. The test item will be subjected to a functional check.

4.1.2 Data Required.

a. Receipt condition of test item.

b. Results of safety inspection.

c. Inventory list of components, BII, and TSP.

d. Serial and model numbers of major components.

e. Operating hours of test item.

f. Results of initial service (break-in).

g. Results of functional check.

h. Repairs or modifications made to the test item.

i. Photographs.

4.1.3 Data Presentation.

The condition of the test item upon receipt; results of the safety inspection, initial service, and functional check; and any repairs or modifications made to the test item will be presented in narrative format or tables and supported with photographs. The inventory list, serial and model numbers, and operating hours will be presented in tables.

4.2 Operator and Maintainer Training.

4.2.1 Method.

a. All prototype equipment will be accompanied by a training package supplied by the manufacturer under the auspices of the MATDEV. Previously tested equipment may, by consensus of the US Army Test and Evaluation Command (ATEC), ATEC Systems Team (AST), be limited to refresher training to ensure proper operation of the test item. The facilities and personnel will be scheduled as required. Trainers will instruct the test team in the capabilities, assembly, operating and maintenance procedures, disassembly, and storage of the system.

b. The NET should encompass all operational tactics, techniques, and procedures (TTPs) associated with the operation of the vessel and requisite support equipment.

c. The NET should also encompass all preventive maintenance checks and services (PMCS) activities to occur during the test and evaluation period.

d. Training should be comprehensive, be concise, and include hands-on demonstration of the required tasks to ensure adequate familiarity by test personnel.

e. Test crew members will complete a Test Participant Demographic Data Form (Appendix B, Form B-1) to document their current position/rank, experience, and previous training.

f. The crew, support personnel, and manufacturer's technical representatives will be provided an overview of the test requirements, administration and site security procedures, and test schedule. A risk assessment and Job Hazard Analysis (JHA) will be prepared for review and signature, and a copy of both will be posted at the test site(s). A copy of all applicable Material Safety Data Sheets (MSDSs) will be provided for review and posted at the test site(s). General test facility hazards and safety precautions will be reviewed.

g. The adequacy and completeness of the TMs and/or other instructional materials used for training purposes will be recorded. After NET, test personnel will complete a NET questionnaire (Appendix B, Form B-2). All hardware or software incidents, maintenance performed, and parts replaced to repair the pump during training will be recorded.

h. After completion of training, personnel will demonstrate their ability to operate and maintain the vessel and ancillary equipment without injury to personnel or damage to equipment.

4.2.2 Data Required.

A list of attendees, trainers, dates and times of testing, type of training (classroom or hands-on), and the material covered will be recorded to validate the training.

4.2.3 Data Presentation.

Each respondent will be assigned a numerical code. Demographic data forms and NET questionnaires will be summarized in tables. TM or training inadequacies will be summarized in a table. The data will be presented in tables, charts, or narrative formats to include the information in paragraph 4.2.2.

4.3 Physical Characteristics.

TOPs 01-2-504[12], 02-2-800[13], and 02-2-801[14] will be used as general guides during testing.

4.3.1 Method.

a. The physical dimensions (length, width, height, etc.) of the test item will be measured, and when practical for vessels small enough to be considered for road, rail, or marine transport, the weight, weight distribution, and center of gravity (CG) measurements of the test item will be determined using the weight reaction method.

b. Measurements will include all required configurations and may involve data collection in subsequent phases, such as during stability testing. Modular and component determinations will be made at the appropriate stage of assembly. When required, the test agency may request separate samples of materials for laboratory analysis from the manufacturer. Special tests, as shown in Table 1, are planned for determining strain, fatigue, and material characteristics.

TABLE 1. SPECIAL TESTS

TEST	STANDARD
Magnetic particle test	Naval Sea Systems Command (NAVSEA) Tech Pub T9074-AS-GIB-010/271[15] and TOP 03-2-807[16]
Liquid penetrant	NAVSEA Tech Pub T9074-AS-GIB-010/271, and TOP 3-2-807
Hardness	American Society for Testing and Materials (ASTM) E-18[17] and TOP 03-2-806[18]
Electrical installations	Institute of Electrical and Electronics Engineers (IEEE) Standard 45[19]
Seam strength (inflatables)	Federal Standard (FED-STD)-601, Test Method 8311[20]
Attachment strength (inflatables)	Royal Institute of Naval Architects (RINA) NCC/C.41[21]

4.3.2 Data Required.

a. Physical dimensions.

b. Weight and weight distribution (small craft).

c. CG measurements.

d. Photographs.

4.3.3 Data Presentation.

The data will be presented in narrative form, in tables, and supported with photographs.

4.4 Safety.

The safety subtest takes cognizance of the scope of marine operations, including long-term occupancy of vessels, and the harshness and remoteness of operational locales. The test also ensures the incorporation of applicable marine safety provisions, including the conduct of firefighting (delineated in CFR 46 25.30-15[22]) and lifeboat drills and habitability, with particular emphasis on communications during at-sea and night operations. Reference is made, as necessary, to such guidance as US Coast Guard regulations, rules of international convention for SOLAS, and applicable safety directives and Safety-of-Use Messages (SOUMs). TOP 01-1-060[23] will be used as a general guide for the safety evaluation.

4.4.1 Method.

a. SAR Review. The Test Officer will review the SAR to identify all developer- or contractor-identified safety and health hazards. The hazards and means of mitigation identified in the SAR will be verified during the operator/maintainer test team training when the TMs are received.

b. Inspection and Operation. A system-specific hazards checklist derived from TOP 10-2-508[24] will be completed during the safety inspection. Representative surface temperatures will be measured using a contact or infrared temperature measurement device to identify whether any thermal contact hazards exist. Temperatures will be compared with the temperature exposure limits in MIL-STD-1472G[25], Table XXXI. Moving and rotating parts will be checked for the presence of guards. All signs, labels, and other designators, with particular emphasis on warning placards, will be checked for appropriate location, security, content, format, and readability in accordance with MIL-STD-130N[26]. All safety-related incidents or concerns will be reported, and physical configuration safety hazards will be photographed.

c. Safety Devices and Equipment. The types, locations, and rating/certifications for safety and warning devices on the system will be recorded. The adequacy and functionality of the devices will be verified, to the maximum extent possible, without causing harm to the item. For example, pressure relief valves will be inspected to determine whether they discharge down and away from personnel occupied areas. The type, size, storage location, and means of positive securement of the fire extinguisher will be recorded.

d. Noise. Noise testing is addressed in paragraph 4.5.

e. Petroleum, Oils, and Lubricants (POL). During petroleum pump testing and POL handling operations, safety precautions, as specified in Field Manual (FM) 10-67-1, Chapter 2[27], will be observed.

4.4.2 Data Required.

a. SAR.

b. Inspection and Operation.

(1) Safety hazards checklist.

(2) Safety- or health-related incidents or concerns.

(3) Adequacy of safety instructions in the TMs.

(4) Results of the physical inspection of the system verifying the provision of warning or caution placards as listed in the SAR and/or TM.

(5) Photographs of safety-related physical configuration concerns.

c. Safety Devices and Equipment.

(1) Identification (type and purpose) of safety and warning devices.

(2) Methods and results (suitability, adequacy, proper operation, and malfunctions) of safety/warning device tests.

(3) Recommendations for additional or improved safety or warning devices.

4.4.3 Data Presentation.

Potential safety hazards will be summarized in a table. If the system is being evaluated, the hazards will be classified for hazard probability and severity in accordance with DA PAM 385-16[28]. Recommendations to mitigate the hazard(s) will be made. Results of the safety device and equipment inspections and tests will be summarized in paragraph or tabular form. Recommendations will be made to improve the safety devices, warning/caution placards, and TM procedures.

4.5 Seaworthiness.

4.5.1 Watertightness.

4.5.1.1 Method.

a. Before being placed in the water, the hull will be inspected to ensure all bilge plugs are in place and tight, and all sea valves are closed. The vessel will be launched in calm water of sufficient depth and secured to a dock or pier. The vessel will be loaded with properly distributed deadweight cargo to the design capacity or displacement. At the end of a specified period, or as stated in the PD or other criteria, hull, bilge areas, and piping below waterline will be visually inspected for leaks.

b. Deckhouses and areas above the waterline will be subjected to water hose tests. All doors, hatches, ports, and other hull openings will be closed tightly or blanked (in case of vents). Water will be applied at 50 pounds per square inch (psi) pressure (± 5 psi), from a 1-1/2-inch inside diameter hose with a 1-inch nozzle full open, positioned not more than 10 feet (ft) from the surface being tested. The spray will be applied at a rate of 1 minute per square yard of test surface. Visual inspection will be made of internal areas opposite the applied stream of water.

c. Inflatable items will be loaded with sandbags or weights to simulate intended personnel seating, with at least three inches of freeboard remaining, positioned so that the boat or raft remains level while afloat. The test item will be left floating for the specified period and inspected periodically for leakage. Tests will be run on multiple samples when specified.

d. Some items may be placed directly on the Rain Course as specified in TOP 10-2-021[29] and subjected to controlled rainfall conditions. When a hose test is not practical, air under pressure may be applied, and a soap solution will be used on the opposite side of the structure at

seams and closures. Internal tanks may be tested by filling to the top of the overflow with the liquid to be carried, allowing the item to stand for 24 hours, and inspecting for leakage. Small inflatables may be pressurized, weighted and submerged in water, and observed for bubbles as an indication of leakage.

4.5.1.2 Data Required.

a. Any evidence of ingress of water into watertight enclosures or egress of air from flotation modules.

b. Type of testing used (e.g., spray hose, controlled rainfall from calibrated rain facility, weighted submersion of vessel (inflatable craft only)).

4.5.1.3 Data Presentation.

Data will be presented in the form of written test plans/reports that include text documents, spreadsheets, charts, and photographs.

4.5.2 Stability.

4.5.2.1 Water Method.

Stability characteristics are determined by locating the CG, metacentric height (GM), and transverse radius of gyration of a craft. To determine CG for small items capable of suspension with available lifting facilities, procedures in TOP 02-2-800 are used, either suspension or reaction methods, and the location is recorded with respect to the baseline, centerline, bow, and stern. For larger vessels, an inclining experiment is used to determine the vertical CG and GM. The experiment with the vessel afloat is accomplished by positioning a known weight at known distances on either side of the vessel's centerline, producing various angles of heel. From these data, the GM can be calculated. By using the GM, vessel draft, and certain vessel design drawings, the CG is computed.

a. Preparing for Tests (refer to Society of Naval Architects and Marine Engineers, Naval Architecture for Non-Naval Architects, 1991, pages 68-71[30]).

(1) Drawings and Data. Vessel design data will be obtained, including the line's drawing, table of offsets, curves of form, hydrostatic curves, amidships sections, profiles, arrangement and deck plans, tank tables, and sounding information. Data include calculated displacement, baseline identification, longitudinal and vertical center of buoyancy, tons per inch immersion, moment to trim one inch, and molded dimensions.

(2) Environment. Selected water should be calm and at slack tide. Inclement weather should be avoided. Wind can seriously affect the validity of the results. Rain, snow, and ice can result in added weight. The vessel should be moored in quiet, sheltered water free of current, propeller wash from passing craft, or sudden pump discharges. Depth of water must be

sufficient to ensure that the hull will be entirely free of the bottom. Tide conditions, trim, and list of the vessel under test must be considered.

(3) Inclining Weight. The total weight used should be sufficient to give an inclination of 2 to 3 degrees to each side, with the larger inclinations necessary to get sufficient deflection of the pendulum on smaller vessels. The inclination should never exceed 4 degrees. The weights should be compact and of such configuration that the vertical CG may be accurately determined (persons are not acceptable as weights). The weights must be capable of being moved rapidly once the test is started to reduce the likelihood of encountering changing wind or current conditions. The transfer of liquids between tanks is not acceptable. Precautions should be taken to ensure that the decks are not overloaded during weight movements. The weight and an identification number should be marked on each weight.

(4) Pendulums. When possible, three pendulums should be used to allow for possible bad readings at any one pendulum station. The pendulums should be located in an area protected from the wind. The pendulums should be as long as possible to allow for maximum deflection at the batten. A typical satisfactory arrangement is shown in Figure 1. The pendulums do not have to be on centerline. The battens should be smooth, light-colored wood, 1/2- to 3/4-in. thick, and must be securely fixed in position so that an inadvertent shock will not cause them to shift. A weight should be attached at the end of the pendulum. The bucket is used to dampen the swinging of the pendulum, thereby stabilizing the arrangement.

Note: It is possible to substitute inclinometers for the pendulums except that inclinometers are less desirable because of their short length of pivot arm.

(5) Condition of the Vessel. The craft must be fully equipped with all attachments, accessories, repair parts, and assigned tools. The Test Officer should verify that all items are onboard and stowed in their assigned locations. Moveable weights must be lashed in place. Bilges must be dry and decks free of liquids. All wet machinery and piping should be at operating liquid level. All tanks should be either completely filled or completely empty. For purposes of the stability evaluation, it is recommended that the tanks be completely filled with their assigned liquids. The vessel should not have a list at the start of the inclining experiment. Leveling weights may be used to correct list. It is essential that the exact status of the vessel be known as it exists at the time of inclining. A list should be prepared indicating the weight and location of the CG of all heavy objects that are not considered part of the vessel attachments or accessories, including leveling weights, personnel, dunnage, stores, tankage, etc. To ensure satisfactory communications during the inclining experiment, it is recommended that a telephone system with headsets be furnished to allow for two-way communications between the central control station, the weight handlers, and each pendulum station.

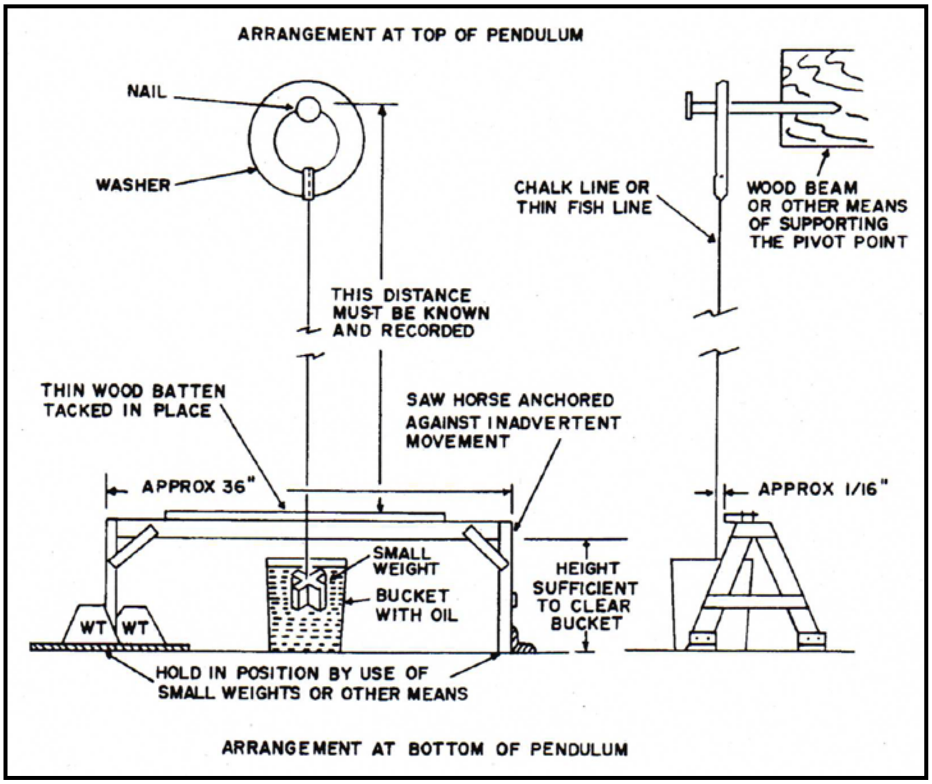
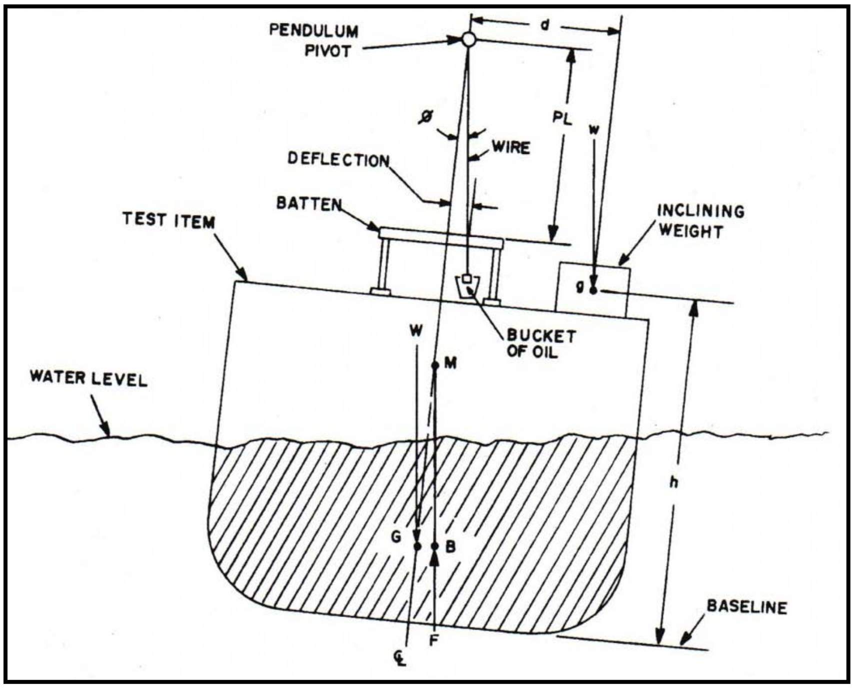


Figure 1. Pendulum arrangement for inclining experiment.

(6) Trim, List, Draft, and Freeboard. Drafts and/or freeboards will be read immediately before or immediately after the inclining experiment. All persons who will be onboard during the inclining experiment should be onboard and in the location during these readings. If the readings are done after the inclining test, the vessel must be maintained in the same condition as during the test. Lines will not be slacked, however, if the list is not significantly changed. Drafts will be read at the forward and aft draft marks, and a freeboard measurement will be obtained amidships to determine hog or sag. As a check on draft marks and hog or sag, additional freeboard readings may be taken at the bow, stern, and other convenient locations near the fore and aft quarter lengths. All readings will be obtained both port side and starboard side except for bow and stern freeboard readings, which will be obtained on centerline. The fore and aft distances of the readings from fixed reference points will be recorded. It may be necessary to counterbalance the list and trim effect of freeboard measuring parties. When possible, all readings should be obtained from a boat; however, all persons (or equivalent weights) that will be onboard for the test should be onboard during the readings. A small boat must be available for use when obtaining draft and freeboard readings. The boat should have a low freeboard to permit accurate observation of the readings.

b. Inclining Experiment (see Figure 2).



where:

G	=	CG of the boat.
B	=	center of buoyancy of the submerged portion.
M	=	Mmetacenter.
g	=	CG of the inclining weight.
W	=	weight of the boat (in pounds).
w	=	weight of the inclining weight (in pounds).
F	=	force of flotation.
h	=	distance between the baseline and the CG of the inclining weight.
d	=	distance between the CG of the boat and the CG of the inclining weight (in feet).
ø	=	angle of inclination.
GM	=	metacentric height - the distance between G and M.
PL	=	the length of the pendulum measured at the wooden batten inclining moment = d multiplied by w.

Figure 2. Setup for inclining experiment.

(1) The Test Officer will ensure that the vessel is ready for inclining and that no condition of list exists.

(2) The inclining weight will be positioned on one side of the vessel centerline, and the distance from centerline will be recorded.

(3) A check will be made to ensure that all mooring lines are slack.

(4) A check will be made to ensure that all personnel are at their assigned stations and that the communications system is functioning properly.

(5) The vessel will be allowed to become still in the water.

(6) Upon the word “mark,” all pendulum station attendants will mark the batten with a soft pencil at a point corresponding to the location of the pendulum wire.

(7) The inclining weight will be positioned on the opposite side of the vessel centerline at the same distance as described in step (2).

(8) Steps (5) and (6) will be repeated to obtain a second mark on each of the battens.

(9) Each pendulum attendant will divide the distance between the two marks in half. This midpoint will be labeled 0 (zero).

(10) The inclining weight will be placed at a predetermined location approximately one-fourth the distance between the vessel centerline and the starboard gunwale. This distance will be measured and recorded.

(11) The vessel will be allowed to become still in the water, and at the word “mark” each pendulum station attendant will mark the batten at a location corresponding to the position of the pendulum wire. The resultant mark will be labeled No. 1.

(12) The inclining weight will be positioned at a predetermined location approximately one-fourth the distance between the vessel centerline and the port gunwale.

(13) The vessel will be allowed to become still in the water, and at the word “mark” each pendulum station attendant will mark the batten at a location corresponding to the position of the pendulum wire. This mark will be labeled No. 2.

(14) The process will be continued until marks are obtained for inclining weight positions at approximately one-half and three-fourths the distance between the vessel centerline and gunwale, both port side and starboard side.

(15) Before ending the inclining experiment, a plot will be made to determine whether satisfactory values have been obtained: the tangents of the angles of inclination will be plotted against the movements of the inclining weights (see Figure 3 for a typical plot of tangents versus moments). Variations of the resultant plot from a straight line indicate that conditions are not favorable or that an error has been made. When only one point does not agree satisfactorily with the other readings, it may be appropriate to disregard it and accomplish the plot using the remaining information. When the plot does not result in a straight line, it may be necessary to repeat the experiment.

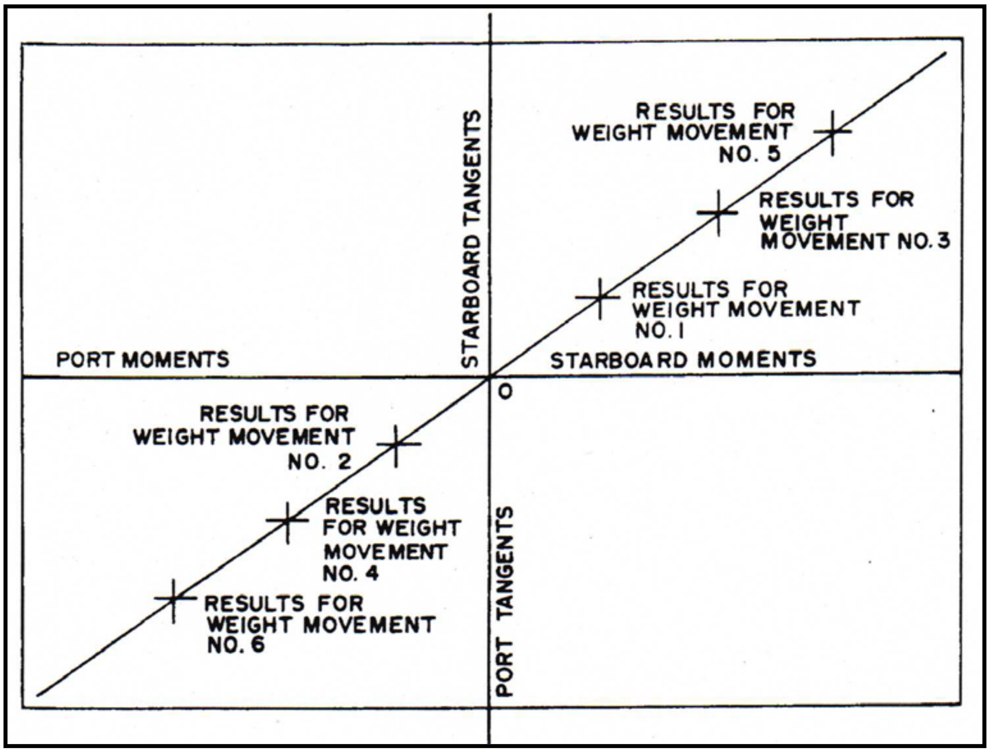


Figure 3. Typical plot of tangents versus moments.

(16) The following data will be recorded:

(a) w = amount of inclining weight used.

(b) h = distance (height) of inclining weight above the baseline.

(c) d = distance for each inclining weight position.

(d) PL = length of pendulum measured at the wooden batten. Amount of deflection for each inclining weight position.

(e) Δ = total displacement of the vessel.

(17) The GM will be calculated using the following equation and the average of values obtained.

$$\overline{GM} = \frac{W \cdot d}{\tan\Theta \cdot \Delta} \qquad \text{Equation 1}$$

(18) The wooden battens used during the inclining experiment (labeled station 1, 2, etc.) will be retained for later use in confirming any doubtful values.

c. Transverse Radius of Gyration. The transverse radius of gyration is represented by k in the following equation:

$$\overline{T} = \frac{1.108k}{\overline{GM}} \text{, natural period of roll in seconds} \qquad \text{Equation 2}$$

where:

$\overline{GM}$ = Metacentric height in feet.
k = transverse radius of gyration in feet.
T = roll period in seconds for GM in units of feet.

d. After the value k has been obtained, the approximate $\overline{GM}$, at any time, can be determined by ascertaining the natural period of roll as follows:

(1) A vertical downward force is applied on the gunwale of the vessel to incline it to approximately 10 degrees.

(2) The downward force is removed and the vessel is allowed to roll.

(3) The natural period of roll is determined by measuring the total elapsed time for a number of rolls and dividing by the number of rolls observed. The period of roll to be used in the equation is that of a full cycle.

(4) The value of the natural period of roll and the second transverse radius gyration are calculated and recorded.

4.5.2.1.1 Data Required.

a. Before the tests:

(1) Condition of vessel (para 4.5.2.1a(5)).

(2) Draft of vessel, fore, and aft.

(3) Condition of vessel trim and list at time of experiment.

(4) Wind direction and velocity.

(5) Set and drift of current.

(6) Specific gravity of the flotation water. (Indicate saltwater or freshwater.)

(7) Depth of water at mooring location.

(8) Measured CG.

b. During the tests:

(1) Amount of corrective weight added to improve conditions of list. (Indicate location.)

(2) Amount of inclining weight (w) used.

(3) Height of inclining weight above baseline.

(4) Distance (d) for each inclining weight position.

(5) Length (PL) of pendulum measured at wooden batten.

(6) Amount of deflection for each inclining weight position.

(7) Calculated value of GM.

(8) Natural period roll.

(9) Force to produce 10 degrees list.

(10) Transverse radius of gyration.

(11) Plot of tangents of angle of inclination versus inclining moments.

4.5.2.1.2 Data Presentation.

Results of the stability tests will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events. Data will be compared with manufacturer's expected results, and any significant deltas will be evaluated by the Integrated Product Team (IPT), manufacturer, and MATDEV for resolution.

4.5.2.2 Land Method (Air Incline).

The stability characteristics derived from roll response while the vessel is floating can also be acquired on land. The techniques for doing so are delineated in the procedures below. Stability characteristics are determined by locating the CG, GM, and transverse radius of gyration of a craft. To determine CG for small items capable of suspension with available lifting facilities, procedures in TOP 02-2-800 are used, either suspension or reaction methods, and the location is recorded with respect to the baseline, centerline, bow, and stern. For larger vessels, an inclining experiment is used to determine the vertical CG and a GM. The experiment with the vessel aground is accomplished by installing water tubes to measure heeling moment as created by the positioning of known weights at known distances on either side of the vessel's centerline, producing various angles of heel. The GM can be calculated from these data. By using the GM, vessel draft, and certain vessel design drawings, the CG is computed.

a. Preparing for Tests. A list of typical equipment needed is provided in Table 2.

TABLE 2. EQUIPMENT REQUIRED

NOMENCLATURE	USE	MODEL	MANUFACTURER	SERIAL NO.	CALIBRATION REQUIREMENTS	RANGE/ACCURACY
4 Sets water tubes[a]	Determine angles of heel and trim				Not required	Not Applicable
Digital level	Determine angles of heel				Self-level	±0.1 deg
4 Load cells (compression)	Weigh craft				Certified	25,000 ± 25 lb
Lead test weights	Create heeling forces				Not required	Approximately 54 lb/weight total = 1,300 lb
Deck protection material	Protect deck surfaces during testing				Not required	Weighed and marked prior to the test
Scale	Weigh all test equipment				Certified	200 ± 2 lb
Tape measure	Measure test equipment locations				Not required	25 ft to 30 ft ± 1/16 in.
2 Tape measure	Measure pick height				Not required	25 ft to 30 ft ± 1/16 in.
2 Plumb bobs	Verify plane of measurements				Not required	NA
2 Stepladders	Mark water tubes				Not required	8 to 12 ft
Digital camera	Photo-document				Not required	Not Applicable
Lifting yokes (fore and aft) with lifting pins (4)	Lift the BEB				Not required	Not Applicable

[a]Use clear tubing for water tubes.

(1) Acquire and record pertinent accountability information for the equipment delineated in paragraph 4.5.2.1a(5). This land-based stability test shall determine the following:

(a) Lightship weight.

(b) Longitudinal CG.

(c) Vertical CG.

(d) Full load appendage draft.

(e) Error analysis.

(f) Moment-tangent slope.

(2) Procedure Review. The test team and Government witnesses will review the documented procedures to ensure understanding and to validate compliance with industry standards.

(3) Test Weights. Determine the weight (in pounds) of each test weight and assign an identification number; mark weight and number on each test weight using permanent marker. On the Incline Weight Data Sheet (Table 3), record the test weight identification number and the weight's location within its location designation group. A Government representative will witness the weighing of the items.

TABLE 3. INCLINE WEIGHT DATA

WEIGHT GROUP	ID No.	WEIGHT LB.	LOCATION IN GROUP, (U/M/L,F/A)*	DISTANCE FORWARD OF CENTERLINE REFERENCE (inches)	DISTANCE FROM CENTERLINE REFERENCE (inches) (STBD* is + nos., PORT is – nos.)	DISTANCE ABOVE MAIN DECK (inches)
A	A1					
	A2					
	A3					
	A4					
B	B1					
	B2					
	B3					
	B4					
C	C1					
	C2					
	C3					
	C4					
D	D1					
	D2					
	D3					
	D4					
E	E1					
	E2					
	E3					
	E4					
F	F1					
	F2					
	F3					
	F4					

*References are: Upper (U), Middle (M), Lower (L), Forward (F), Aft (A), Starboard (STBD)

(4) Deck Protection. Apply protective material to the vessel deck where weights will be placed.

(5) Environmental Considerations. Winds must be calm enough that a static heel moment is not induced to the craft and the craft comes to rest for incline water tube readings.

(6) Vessel Setup. Set up the lifting yokes using the example in Figure 4. Fill and set up the water tube levels on the craft. Mount three water tubes for recording heel during the test. Mount each tube to a flat marking surface with a paper attached behind to mark the tube level, as shown in Figures 5 and 6. Run each tube from the marking surface on one side of the craft, down to the deck, across the deck, and up to the marking surface on the opposite side. Ensure all air pockets and bubbles are evacuated from the water tubes. Measure and record the transverse distance between the vertical columns of each water tube on the incline test data sheet as “distance apart.” Mount a fourth water tube longitudinally on centerline so that it may be used to verify that the rotational axis is horizontal and parallel to the main deck.

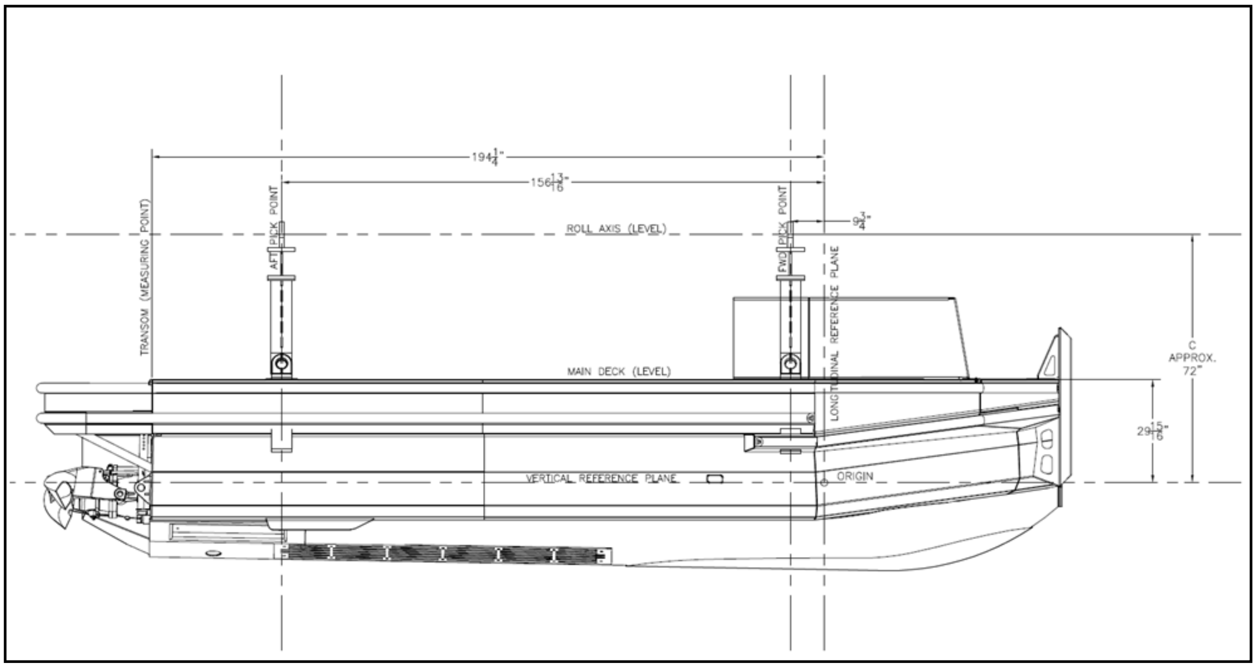


Figure 4. Lifting yoke arrangement.

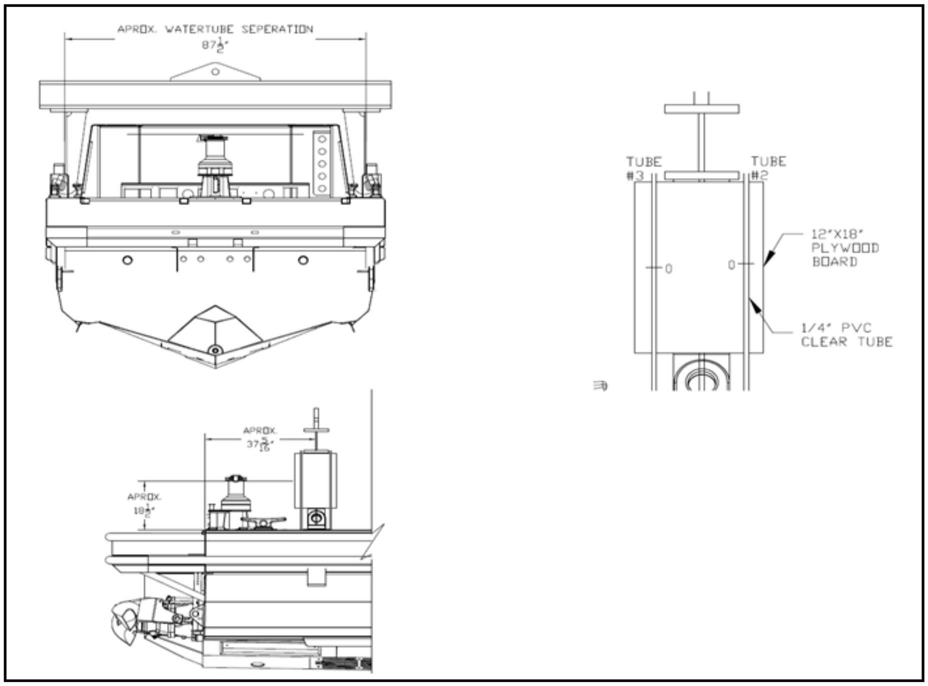


Figure 5. Water tube arrangement.

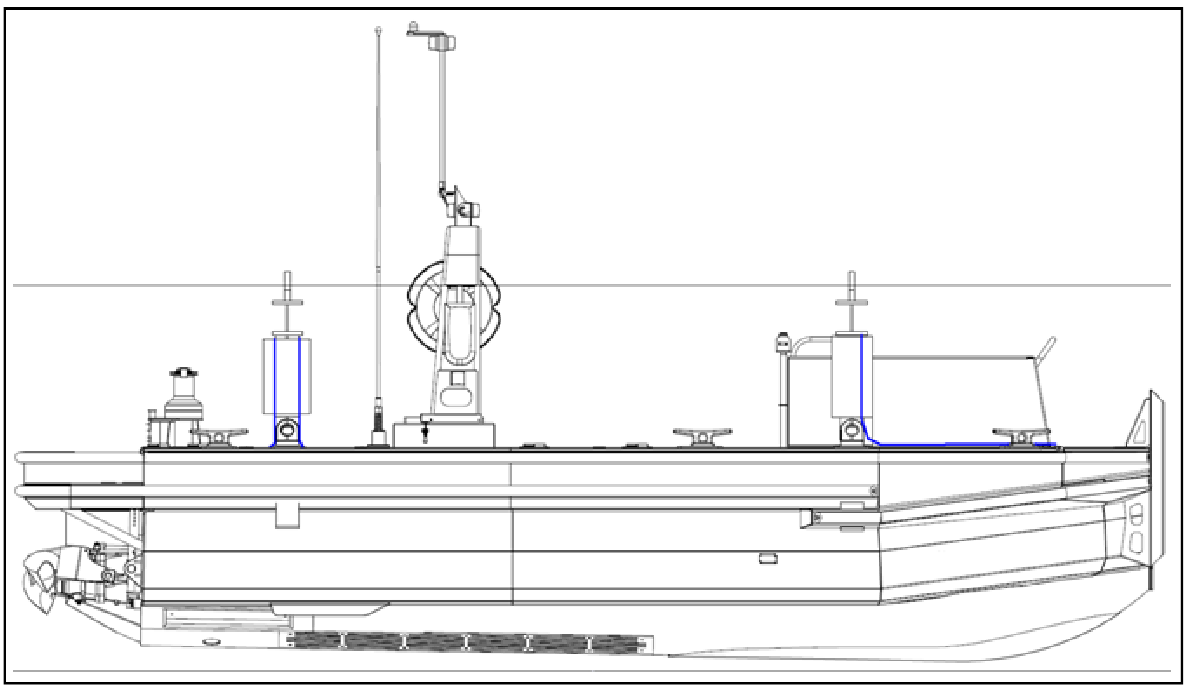


Figure 6. Water tube setup locations.

b. Conduct the Incline Experiment.

(1) Position the weights in their original locations, as shown in Figure 7, stacking the weights two high in all positions. Record the original position of the test weights on the Incline Weight Data Sheet, and mark their locations on the deck protection material. On a plan view of the vessel, indicate the original locations of the weight groups.

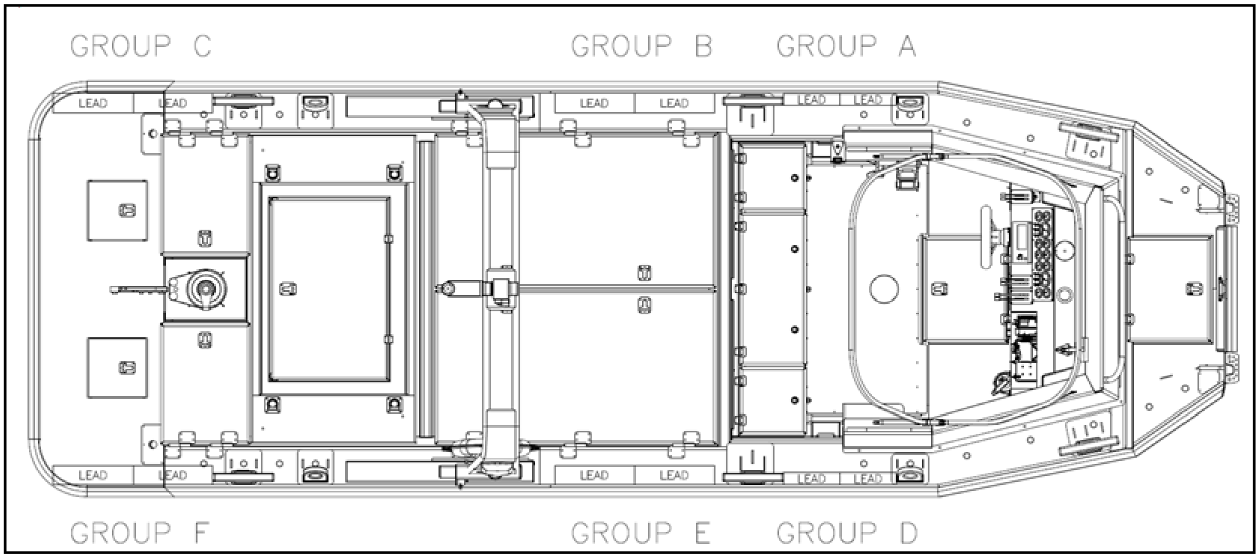


Figure 7. Weight placement.

(2) Deadweight Survey. Ensure the vessel is complete and clean, with no standing water in bilges, on deck, or in sumps, and all operational liquids are topped up. Ensure the vessel satisfies a Light Ship Condition, except that the fuel tank will be full and the "future material additions" will be treated as a weight to add. Sound all fluid tanks and record their levels in Table 4. Any “dummy weights” used during the scale weight test may be used during the incline, provided that the positions of such weights may be secured so that they remain stationary during the test and the CGs represented by the weights are accurate. If any items do not meet the Light Ship Condition, record weights to remove, add, or relocate on the deadweight survey data sheets presented in Tables 5 and 6.

TABLE 4. SAMPLE TANK SURVEY LIST

NO.	ITEM	CONTENT[a]	DESIRED CONDITION (REF. VOLUME)	ACTUAL CONDITION (SOUNDING, ULLAGE, OTHER)
1	Fuel tank	DO	Full	
2	Hydraulic tank and system	HYD	Full (at least 3/4 of sight glass)	
3	Engine coolant (keel cooler), port	FW	Full to cap	
4	Engine coolant recovery bottle, port	FW	Empty	
5	Engine fuel system, port	DO	Empty	
6	Engine lube oil, port	LO	Full per dipstick	
7	Gear oil lube, port	LO	Full per dipstick	
8	Jet lube oil, port	LO	Full per dipstick	
9				
10	Engine coolant (keel cooler), stbd	FW	Full to cap	
11	Engine coolant recovery bottle, stbd	FW	Empty	
12	Engine fuel system, stbd	DO	Empty	
13	Engine lube oil, stbd	LO	Full per dipstick	
14	Gear oil lube, stbd	LO	Full per dipstick	
15	Jet lube oil, stbd	LO	Full per dipstick	
16	Fuel raw water strainer, port	SW	Empty	
17	Fuel raw water system, port	SW	Empty	

[a] Diesel Oil (DO), Hydraulic Fluid (HYD), Fresh Water (FW), Lube Oil (LO), Salt Water (SW)

TABLE 5. DEADWEIGHT SURVEY DATA SHEET (ADD/REMOVE)

WEIGHTS TO : ADD REMOVE (circle one)						
REFER TO THIS SHEET AS LETTER___:			LONGITUDINAL LOCATION		VERTICAL LOCATION	
ID	DESCRIPTION	WEIGHT, (LB)	FRAME NO.	DISTANCE FORWARD OF TRANSOM (INCHES)	DECK NO.	DISTANCE FROM MAIN DECK (INCHES)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
12						
13						
14						
15						
16						
17						
18						

TABLE 6. DEADWEIGHT SURVEY DATA SHEET (RELOCATE)

REFER TO THIS SHEET AS LETTER__:						
DESCRIPTION	WEIGHT, (LB)		FRAME NO.	DISTANCE FORWARD OF TRANSOM (INCHES)	DECK NAME	DISTANCE FROM MAIN DECK
1		from:				
		to:				
2		from:				
		to:				
3		from:				
		to:				
4		from:				
		to:				
5		from:				
		to:				
6		from:				
		to:				
7		from:				
		to:				
8		from:				
		to:				
9		from:				
		to:				

(3) Suspend Vessel. Suspend the craft so the keel is approximately three inches above the ground/blocks. While maintaining the height of the forward yoke pin point, adjust the height of the aft yoke so the rotation axis and main deck are both level horizontally. Use a plumb bob to confirm that the lifting gear is vertically oriented. Use the longitudinally oriented water tube to confirm the roll axis is level and the digital level to confirm the main deck is level, such that the roll axis is parallel to the main deck. Measure and record the heights of the knife-edge roll axis above the deck, or cockpit floor, at the longitudinal location of the pick points in the incline data sheet presented in Table 7. This height is to be added to the distance from the reference plane to the main deck, D, to determine height C, used for calculation of vertical center

of gravity (VCG) in paragraph 4.5.2.2c(2). Use a plumb bob to verify the measurement is made in a vertical orientation. To the extent possible, ensure that measurements are obtained with the tape measure in appropriate alignment; however, small angles of misalignment in measurements will not introduce significant error. Measure and record the longitudinal distance of each pick point from the reference point. For longitudinal measurements, utilize the plumb bob or other reference tools as appropriate to ensure the tape measure is oriented horizontally and parallel to centerline as close as practicable. Measure distance with a steel tape measure accurate to 1/16 inch.

TABLE 7. INCLINING EXPERIMENT DATA SHEET

movements and deflections to PORT are NEGATIVE
movements and deflections to STBD are POSITIVE

Water tube #1 Description		
Water tube #2 Description		
Water tube #3 Description		
Air Temperature (start)		
Air Temperature (final)		
D, depth from baseline to top of deck		(Reference physical test)

Pick point locations (at "knife edge")

	Height above deck (in)	Dist fwd of Ref (in)	Scale Reading (lb)
Fwd Point			
Aft Point			
Height C		(Height above deck + D)	

Note: Height above deck of fwd and aft pick points should be identical

	Water tube #1	Water tube #2	Water tube #3	Units
Distance apart				in
Deflection 0	+ =	+ =	+ =	in
Deflection 1	+ =	+ =	+ =	in
Deflection 2	+ =	+ =	+ =	in
Deflection 3	+ =	+ =	+ =	in
Deflection 4	+ =	+ =	+ =	in
Deflection 5	+ =	+ =	+ =	in
Deflection 6	+ =	+ =	+ =	in
Deflection 7	+ =	+ =	+ =	in
Deflection 8	+ =	+ =	+ =	in

Move (#)	Weight (lbs)	Distance (in)	Moment (in lbs)	Total Moment (in lbs)

(4) Perform a preliminary weight move prior to collecting the actual experiment test data to confirm that the setup of the experiment will give results within the expected ranges. Move approximately half of the test weight (one quarter of the total test weight) from one side of the craft to the other while maintaining the same longitudinal position. The net deflection of the water tubes (sum of port and starboard deflection) should be approximately two inches. Return weights to their original positions. Test personnel may vary the amount of incline weight to achieve desired deflection of approximately two inches.

(5) Test Weight Shifting Sequence:

(a) Original weight location (Figure 7).

(b) Group A weights moved to starboard side.

(c) Groups A, B, and C weights moved to starboard side.

(d) Groups B and C weights moved to starboard side.

(e) Return weights to original location.

(f) Group D weights moved to port side.

(g) Groups D, E, and F weights moved to port side.

(h) Groups E and F weights moved to port side.

(i) Return weights to original location.

(6) After each move, allow the craft to reach equilibrium heel. Once the craft settles, mark the level of the water tubes (on the marking boards) and indicate the move number. One recorder will record the three port side tubes, and the other recorder will record the three starboard side tubes. When recording the level, mark the middle of the meniscus for consistency. Keep all personnel off the vessel during water tube measurements. Record the weights moved; measure the transverse distances they were moved (relative to their original locations) and record on the air incline data sheet. The Test Officer will indicate on a plan view of the vessel the locations of weight groups for each move. Alternatively, or in addition, obtain photographs that indicate the locations of weight groups for each move. Longitudinal locations of the weights are not to vary during weight moves. Positive transverse measurements indicate movement to starboard of the original location; negative measurements indicate movement to port of the original location.

(7) Determine Moments and Tangents. Make the following calculations by entering the data into the incline experiment data spreadsheet presented in Table 7. If a computer is not available at time of testing, make the calculations on paper. Determine the transverse heeling moments induced for each weight shift. Multiply the weights shifted by the corresponding transverse distances recorded on the incline data sheet. Positive moments will indicate heeling moment to starboard; negative moments will indicate heeling moment to port. Determine the

tangents of the heel angles achieved for each weight move by dividing the total water tube deflection (port offset from point 0 + starboard offset from point 0) by the length of the water tube, which is the transverse distance between the port and starboard vertical portions of the corresponding water tube recorded in paragraph 4.5.2.2a (6). Water tube deflections for starboard heel will be positive; water tube deflections for port heel will be negative. Note any disparity between tangents determined by different water tubes.

(8) Either on paper or by using the incline test spreadsheet in Table 7, plot the moments (x coordinates) and tangents (y coordinates) for each water tube immediately after the movement sequence is completed. The data points should be very close to linearly coincident. Create linear trend lines based on the data. If a spreadsheet is used, determine the R^2 values (coefficient of determination) to indicate how closely the data correspond to the trend lines. The data points should be very close to linear, and the value of R^2 should be greater than or equal to 0.985. If $R^2 < 0.985$, or if any data indicate deviation from linearity, check calculations and measurements and double-check bilges and tank contents. Rectify the cause of any errant data points. If necessary, redo weight moves to achieve the required minimum accuracy of the test plot. Examples of the inclining experiment data regression and calculations of the incline setup are presented in Tables 8 and 9.

TABLE 8. INCLINING EXPERIMENT DATA REGRESSION
(SAMPLE CALCULATION)

Deflections to port are negative and deflections to starboard are positive.
Water tube No. 1 length - 150 in.
Water tube No. 2 length - 152 in.
Water tube No. 3 length - 148 in.
Total Deflections, Port + Stbd

	Deflection No. 1, in.	Deflection No. 2, in.	Deflection No. 3, in.	Moment, lb	Tangent No. 1	Tangent No. 2	Tangent No. 3	Average Tan
Move 0	0.000	0.000	0.000	0	0.0000	0.0000	0.0000	0.0000
Move 1	1.000	1.100	0.900	300	0.0067	0.0072	0.0061	0.0067
Move 2	3.000	3.100	2.900	1,000	0.0200	0.0204	0.0196	0.0200
Move 3	2.000	2.100	1.900	600	0.0133	0.0138	0.0128	0.0133
Move 4	0.000	-0.100	0.100	-10	0.0000	-0.0007	0.0007	0.0000
Move 5	-1.000	-1.100	-0.900	-325	-0.0067	-0.0072	-0.0061	-0.0067
Move 6	-3.000	-3.100	-2.900	-1,025	-0.0200	-0.0204	-0.0196	-0.0200
Move 7	-2.000	-2.100	-1.900	-625	-0.0133	-0.0138	-0.0128	-0.0133
Move 8				0	0.0000	0.0000	0.0000	0.0000

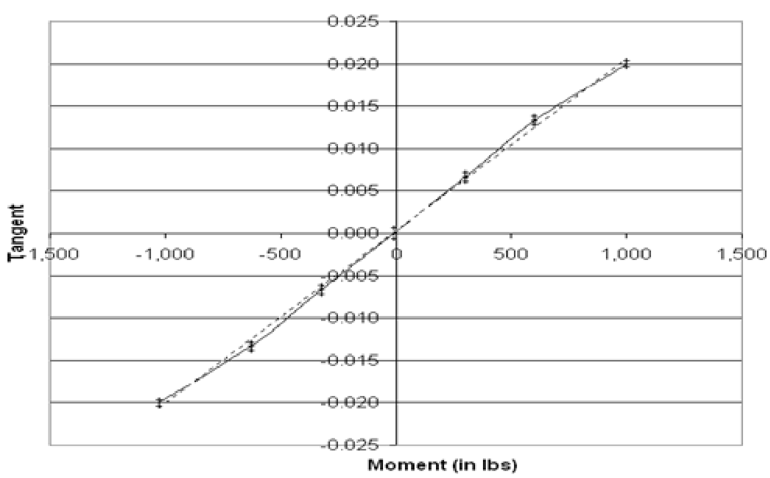


TABLE 9. CALCULATIONS OF THE INCLINE SETUP

item	weight (lb)	VCG (in ABL)	VMOM (in lb)
RB-M	32,900	55.90	1,839,110
Fwd yoke	350	100.00	35,000
Aft yoke	500	84.50	42,250
incline kit	50	70.00	3,500
incline weights	1,542	80.00	123,360
Craft at incline	35,342	57.81	2,043,220

ABL = above baseline
VMOM = vertical moment
RB-M = response boat - medium

Weight	771	lb
Distance	144	in

incline weight = twice required weight to move

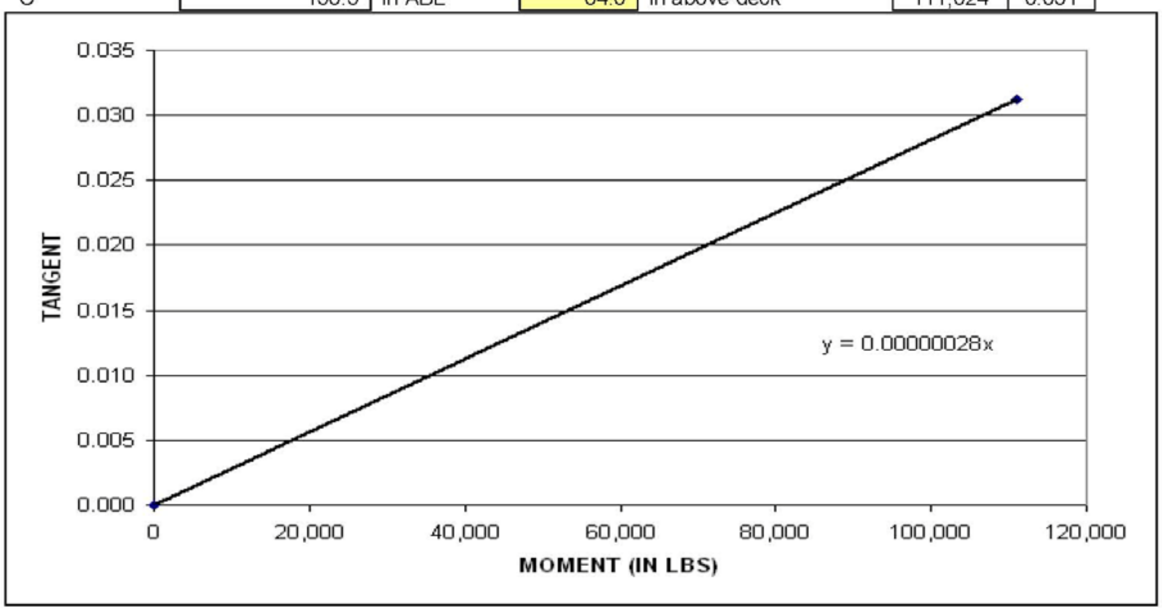
Water tube #1	152.00	in
Water tube #2	150.00	in
Water tube #3	148.00	in

Deflection #1 (in)	Deflection #2 (in)	Deflection #3 (in)	Moment (in lbs)	Tan #1	Tan #2	Tan #3	Avg Tan	avg deg
6.010	6.000	6.020	111,024	0.040	0.013	0.041	0.031	1.79

m = slope =	0.00000028	1 / in lb		
VCG	57.76	in		
W	35342	lb		
C	158.5	in ABL	84.0	in above deck

graph points

X	Y
0	0
111,024	0.031



(9) Lower the vessel onto the load cells, record the readings of the load cells, and measure the longitudinal distance of the load cells from the reference point, as presented in Table 10. After recording the data, remove and weigh the lifting gear (lifting slings, yokes, and shackles), and record the results in the deadweight data sheet for weights to remove. Record load cell readings with no weight on them to check for drift that may have occurred during the test. Remove and weigh all testing gear (water tubes, water tube marking boards, deck protective

covering). If the weight of the craft has already been recorded, enter all the testing gear weight results into the deadweight data sheet for weights to remove.

TABLE 10. VESSEL WEIGHT RESULTS

PARAMETER	WEIGHT, LB	LONGITUDINAL LOCATION
Forward port scale reading		
Forward STBD scale reading		
Aft port scale reading		
Aft port scale reading		
Deadweight data sheet correction for weight to remove		
Deadweight data sheet correction for weight to add		
Deadweight data sheet correction for weight to relocate		
Corrections		
Total weight results		

(10) Average the tangents determined by the three water tubes, create a plot of the averaged incline data, and determine slope and error (R^2 value) of a regressed linear curve fitted to the data.

c. Calculate the incline experiment results.

(1) Calculate as inclined weight and Longitudinal Center of Gravity (LCG):

weight = sum of scale readings forward + sum of scale readings aft Equation 3

LCG = (Dfwd * Wfwd) + (Daft * Waft) / W Equation 4

where:

Wfwd = sum of weights from forward scales
Waft = sum of weights from aft scales
W = Wfwd + Waft = weight of craft as inclined
Dfwd = longitudinal distance of forward scales from the reference point
Daft = longitudinal distance of aft scale from the reference point

(2) Calculate VCG:

VCG = C – 1 / (m * W) Equation 5

where:

C = vertical distance from pivot point to reference point
m = slope of regressed line of moment tangent plot
W = weight of craft as inclined

(3) Calculate total weight to add from the data sheet.

(4) Calculate total weight to remove from the data sheet.

(5) Calculate total weight to relocate from the data sheet.

(6) Calculate light weight of craft from the calculated inclined weight and CG, weight to add, remove and relocate calculations, and tank survey data.

(7) Record data into the form constructed for this purpose. An example is presented in Table 11.

TABLE 11. RESULTS

RESULTS	PERFORM CALCULATIONS AND ENTER BELOW
Displacement (weight): Displacement of the craft can be calculated for any liquid based on the weight of the craft and the specific gravity of the liquid in which the craft is afloat. Since the specific gravity of the fluid in which the craft is floating is not relevant for an air incline test, only the weight of the craft will result.	Weight =
Longitudinal center of gravity (LCG): Enter the LCG of the craft as calculated.	LCG =
Vertical center of gravity (VCG): Enter the VCG of the craft as calculated.	VCG =
Full load appendage draft: Calculate full load appendage draft using the weight and CG calculated from this experiment and enter result into General Hydrostatic Software (GHS). The same modeling standards/practices that were implemented in the BEB stability calculations will be followed and attached to this test procedure.	GHS results to be attached
Error analysis: Perform linear regression analysis of the data that populate the moment versus average tangent plot to determine the coefficient of determination (R^2).	R^2 =
Moment-tangent slope: Determine the slope of the line (m) from the linear regression analysis of the data that populate the moment versus tangent plot based on the algebraic equation of a line (Y = mX + B).	m =

4.5.3 Static Flotation.

4.5.3.1 Method.

a. The vessel is prepared for launching. All hull closures are checked to ensure they are tight. An inclinometer is installed on the vessel centerline as near as possible to the CG. The proper loading for various loading conditions is determined, including consideration of cargo, personnel, gear, stores, equipment, and tank contents. For wheeled amphibians, adjustments are made for proper tire inflation. Loading conditions will include light, full, and any intermediate conditions as specified.

b. One-inch graduations are marked on the hull fore and aft, port, and starboard covering the projected draft range. If hull configuration in the area of the waterline is too irregular, panels may be superimposed.

c. The vessel is launched in very calm water. Minimal or no mooring attachment is used. Sufficient clear depth under the hull is ensured. Ambient temperature and water and wind conditions are recorded. Various vessel attitudes are induced by the programmed loading conditions, and readings are obtained after the vessel is completely stabilized at the test condition.

d. Maximum roll and pitch angles are determined under static conditions by applying torsional forces to the floating vessel to points limited by specifications or design. Torsional forces may be induced by ballasting or shifting the cargo and determined by computing the resulting forces. Another method, applicable to small vessels, is shown in Figure 8.

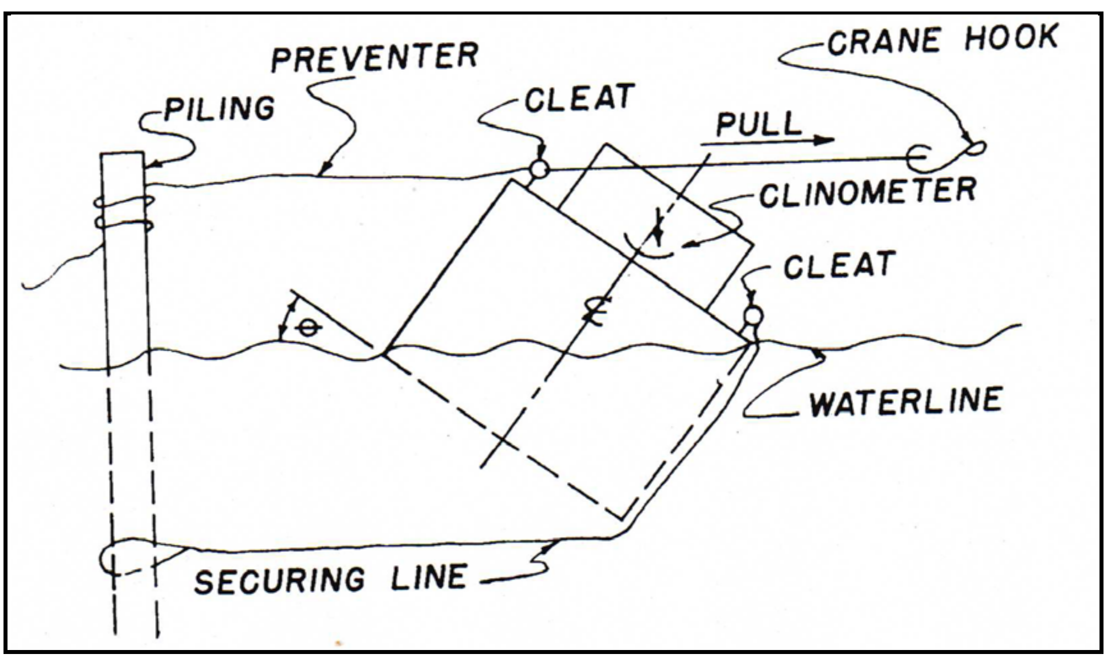


Figure 8. Maximum roll test.

e. Lines are secured to fore and aft mooring cleats and under the hull to piling or other anchorage. Lines from opposite athwartship cleats are run to a tensioning winch or crane. A dynamometer is placed in this line to determine the force of the moment. Padding or fenders are used between lines and structure to avoid chafing damage. Securing and tension lines should be parallel. The tension line should be equipped for quick release to determine vessel righting characteristics and for safety. Safety preventer lines, normally left slack, are used if heeling is expected to approach capsizing condition. Because of symmetry, heel and list determination to one side only may be sufficient. Pitch angles fore and aft may be determined in a similar manner by making line attachments at bow and stern of the vessel, or within crane capacity, by lifting bow or stern separately to limiting angles. For pitch angles the inclinometer must be mounted longitudinally.

4.5.3.2 Data Required.

Drafts are recorded, in inches, for light and loaded conditions, forward amidships, and aft. The resulting freeboard is computed. Roll and pitch angles, for different ballasting, and at maximum values, are measured in degrees. Righting force, in pounds, is read at the dynamometer, load cell, or other force measuring transducer.

4.5.3.3 Data Presentation.

Results of the static flotation tests will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events. Data will be compared with manufacturer’s expected results, and any significant deltas will be evaluated by the IPT, manufacturer, and MATDEV for resolution.

4.5.4 Dynamic Pitch and Roll.

4.5.4.1 Method.

a. Using the method shown in Figure 8 and the quick-release tension hook, the period of roll or pitch can be timed by stopwatch while observing a mark on the vessel as it completes its motion from the port or starboard limited position to its return.

b. When practical, determinations are made during actual operations, with surf and wave conditions, to induce the vessel motions. The vessel in prescribed loading condition is operated through the water, and pitch and roll are monitored by a recording device. Less accurate readings can be obtained with clinometers and stopwatch. Maximum roll is produced when the vessel travels parallel to the waves; maximum pitch is produced when the vessel travels head-on to the waves. Attitudes are measured as peak deviation from the normal plane of flotation of the vessel. Tests are rerun as required for different conditions of loading.

4.5.4.2 Data Required.

Data to be recorded includes vessel loading condition (cargo, passengers, ballasting, tank capacities, and stowed equipment); ambient conditions including wind velocity, wave heights, and wave periods; degrees of roll and pitch; and time in seconds of motion frequency cycles.

4.5.4.3 Data Presentation.

Results of the dynamic pitch and roll tests will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events. Data will be compared with manufacturer's expected results, and any significant deltas will be evaluated by the IPT, manufacturer, and MATDEV for resolution.

4.5.5 Dock Trials.

4.5.5.1 Method.

a. The vessel is securely moored to a pier using sufficient mooring lines, including bow, spring, and stern lines. The pier and lines are of adequate strength to hold the vessel during full-power operation of the propulsion plant. Proper depth of water and cleanliness of water for cooling system intake is ensured. Prior to starting the propulsion engines, the propeller shaft and seals are bled to remove any entrapped air (required for initial start only).

b. The propulsion engine(s) are started in accordance with prescribed instructions and brought up to idle speed. While the engines are warming, a check is made of the engine-driven auxiliaries (instruments, lights, etc.). Other machinery or auxiliaries, such as generator sets, lights, and pumps, are started and checked. A thorough check is made of the hull and piping systems for leaks.

c. The vessel is loaded or ballasted to the trim condition given in the specifications or trials agenda. After engine temperatures are stabilized and all preliminary functional checks are completed, the engines are operated through their ranges in accordance with the schedule provided in the trial agenda. Operation consists of running at selected engine rpm's for not less than 1 hour at each increment, in both forward and reverse gear ranges. During operation, continuous inspection is made of cooling systems, fuel systems, components, and hull openings (e.g., shaft logs, rudder shafts, exhaust outlets) for leakage and all auxiliaries for proper operation. Gauges and instruments are read and recorded, and operational features are checked against the criteria.

4.5.5.2 Data Required.

a. Adequacy of starting and operating instructions for engine and auxiliaries.

b. Readings of all engine, auxiliaries, and system instruments and gauges at the different operational ranges.

c. Indication of proper operation of engines, auxiliaries, components, systems, and accessories (e.g., bilge pumps, fire pumps; cooling, fuel, and oil systems).

d. Evidence of leakage, including description, location, and degree.

e. Adequacy of alignment and coupling (shafts, pump drives, engine couplings).

f. Weather conditions, ambient air and water temperatures.

g. Maintenance and servicing actions required to keep the vessel operational.

h. Hours of operation; description of interruptions, deficiencies, repairs or adjustments required to sustain operations; and corrective measures instituted.

4.5.5.3 Data Presentation.

Results of the dock trials will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events. Data will be compared with manufacturer’s expected results, and any significant deltas will be evaluated by the IPT, manufacturer, and MATDEV for resolution.

4.6 Performance.

4.6.1 Components and Subsystems.

4.6.1.1 Method.

a. The main propulsion machinery; electrical plant and subsystem; auxiliary and emergency machinery; all piping, control, and service systems; deck and special machinery; and hoisting gear and equipment are operated and monitored throughout the entire test period. Initial operability and acceptability are determined during the conduct of the dock and sea trials. Results of those trials serve as a reference for establishing further testing of questionable components, checking for subsequent changes in operating patterns, and reviewing initial compliance with regulatory and specification requirements.

b. In addition to the ordinary operation that occurs, controlled operations are arranged to check or determine particular characteristics, capacities, endurance, or trouble areas. Additional or special instrumentation is provided as required. For detailed tests of specific items, procedures such as those in Table 12 may be used:

TABLE 12. SPECIFIC ITEM PROCEDURES

ITEM	TOP NUMBER
Engines	02-2-700[31]
Power train components	02-2-703[32]
Protective equipment	10-2-021
Pumps	09-2-181A[33]
Generators	09-2-286[34]

c. Systems and equipment not often used such as the emergency generator set, firefighting system, and standby pumps, are operated periodically. Such auxiliaries are operated sufficiently to permit valid judgment as to performance, reliability, durability, and maintainability. Firefighting equipment is checked during regularly scheduled fire drills. During all operations, the electrical system is observed to ensure that all circuits, switching, controls, and components are adequate for their designed functions. Similar observation is made for valve components and manifolds of piping systems. Under appropriate climatic conditions, components of heating, cooling, and ventilation systems are observed. During anchoring, beaching, docking, or cargo movement operations, proper operation of deck machinery and gear is checked.

d. Vessels equipped with outboard engines, with engines installed, are subjected to tests as for other propelled craft.

4.6.1.2 Data Required.

In addition to the usual gauge and instrument data, recorded data include complete information on the occurrence of malfunctions; unusual temperature increase in bearings, motors, or cooling systems; deviations from recommended system parameters; and corrective actions taken. Narrative comments include assessment of capability of items to meet designed requirements.

4.6.1.3 Data Presentation.

Results of the Components and Subsystems tests will be summarized in paragraph, chart, or tabular form to facilitate comparison with manufacturer's technical manuals and system requirements.

4.6.2 Bollard Pull.

4.6.2.1 Method.

a. The vessel is moored to a bollard or other securing device with a rope of sufficient strength to withstand the design pull of the vessel. The mooring line will include a load cell or load cell equipped dynamometer and will run as horizontally as possible from the pier to the vessel's stern towing bitt or cleats.

b. The vessel should be in undisturbed water (i.e. slack tide, no currents, low winds), far enough from bulkheads to prevent influence, and in deep enough water to prevent ground effects.

c. With rudders set on center, engines, having been operated long enough to reach a steady operational state (temperatures and pressures), are operated in forward gear at the maximum engine rpm. Load cell reading is recorded once a steady state pull is achieved.

4.6.2.2 Data Required.

a. Weather conditions, ambient air and water temperatures, wind direction, water current, tidal condition, gauge and instrument readings, and dynamometer readings at each specified engine speed are recorded.

b. The arrangement of all rigging, angles of rigging in relation to the water surface, and ship's hull/deck.

4.6.2.3 Data Presentation.

Results of the bollard pull tests will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events.

4.6.3 Sea Trials.

4.6.3.1 Maneuverability.

4.6.3.1.1 Method.

These trials vary according to the size and type of vessel and the contractual provisions of the procurement action. In some instances, separate Builder's and Acceptance Trials may be required. Trials may be conducted by the contractor, under Army or Navy supervision, or with DoD personnel in monitoring status only. For smaller vessels, complete sea trials are not conducted, but appropriate portions are conducted to ensure the vessel is exercised in a manner consistent with expected usage and maneuvers. Normally, the vessel is crewed by contractor personnel during Builder's and Preliminary Acceptance Trials and by Government personnel during First Article Test (FAT).

a. Preparation for Testing. Trial instrumentation and gear are installed, including shaft revolution counters, torsion meters, flow meters, weight tanks, and other items required to conduct and document the trials. Cargo is adjusted to normal operating condition unless noted otherwise.

b. Standardization Runs. The vessel is operated over an acceptable measured mile course (or over a course using an electronic system for accurate distance measuring). Speed runs are made at 2-knot increments from lowest specified to design full power operation. Runs are made for different conditions of cargo or displacement as specified. Shaft horsepower, propeller rpm, and fuel consumption are recorded.

c. Full Power Ahead. The vessel is operated ahead in open water with the propulsion engines developing design full power for a continuous period of at least two hours. Shaft horsepower, propeller rpm, and fuel consumption are recorded.

d. Astern Operation. The vessel is operated astern continuously for a period of at least two hours. Shaft horsepower, propeller rpm, and fuel consumption are recorded.

e. Maneuvering Trials. Depending on the type of vessel, maneuvers are selected from the following:

(1) Spiral. Runs are conducted in free route, the ahead runs at half and full ahead. The astern runs are conducted at one-third and two-thirds power. Steady turning rate is measured at five degree rudder angles from hardover-to-hardover positions. The helmsman holds the rudder at each angle until a steady heading is achieved before advancing to the next heading. Torsion meter readings are obtained at the propeller shafts.

(2) Zigzag. Runs are made at half and full power ahead, alternating the rudder position from maximum port to maximum starboard. The rudder is held in each position until the vessel heading has been altered 25 degrees either side of the original course heading.

(3) Figure-Eight. At maneuvering engine rpm, a tight figure-eight turn is executed. From full ahead position, the rudder is held hardover until the circle is closed, then hardover opposite until the figure is completed. The maneuver is completed a minimum of 10 times.

(4) Sudden Turns. A selection of runs is made, such as the following in Table 13:

TABLE 13. SUDDEN TURNS

TYPE OF RUN OR TURN
Run straight for 5 minutes.
Execute a sudden 90 ° port turn and run 1 minute.
Execute a sudden 90 ° port turn and run 5 minutes.
Execute a sudden 90 ° port turn and run 1 minute.
Execute a sudden 90 ° port turn and run 5 minutes.
Execute a sudden 90 ° starboard turn and run 1 minute.
Execute a sudden 90 ° starboard turn and run 5 minutes.
Execute a sudden 90 ° starboard turn and run 1 minute.
Execute a sudden 90 ° starboard turn and run 5 minutes.
Repeat this series of maneuvers three times.
From a 0 ° rudder: Execute a sudden hardover to starboard after maximum engine rpm has been reached and continue in a circle for 5 minutes. Repeat with a hardover to port rudder.

f. Sudden Stop. The vessel is operated at full throttle straightaway in the forward direction until the maximum forward speed is maintained at a constant rate. The transmission is shifted from full speed forward to full speed reverse as quickly as possible. Full reverse throttle is maintained until the relative motion of the vessel has stopped. The operation is repeated six times. After each operation hull connections, piping, and machinery are inspected for damage.

g. Steering. With propulsion machinery developing full power ahead, full turning momentum is applied to the rudder to starboard and held steady for 10 seconds. The maneuver is repeated with the rudder to port.

h. Endurance. The vessel is operated under sustained conditions for the period specified and for the specified loading conditions. All vessel-installed and test instrumentation is read regularly, and the information is recorded. When endurance runs cover extended periods requiring plant shutdown and startup, prescribed operation and maintenance instructions are followed, including engine warm-up prior to sustained operations and scheduled maintenance as required.

4.6.3.1.2 Data Required.

a. Records of installed vessel instruments to include engine and other vessel logs and maintenance forms on a regular basis.

b. Weather and sea conditions for each run, including ambient air and water temperatures, winds, currents, surf, and depths.

c. Vessel course, headings, turns, speeds, and maneuvers, roll, pitch, and drafts.

d. Vessel condition of loading or ballasting.

e. Performance and handling characteristics during each operation.

f. Evidence of excessive vibration, malfunction, leakage, inadequate performance, or limiting conditions.

g. Readings of test instrumentation such as tachometers, torsion meters, weigh tanks, stopwatches, etc.

4.6.3.1.3 Data Presentation.

Results of the maneuverability tests will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events. Data will be compared with manufacturer’s expected results, and any significant deltas will be evaluated by the IPT, manufacturer, and MATDEV for resolution.

4.6.3.2 Turning Radius.

4.6.3.2.1 Method.

a. A site is selected with adequate open area and a minimum of current or other disruptive factors. The site should be opposite an on-shore or fixed anchorage observer position as shown in Figure 9. Two buoys are moored, as indicated. The observer site is equipped with a pelorus or transit. The distance (y) is measured and is sufficient to permit the vessel to develop full speed prior to reaching the turn point.

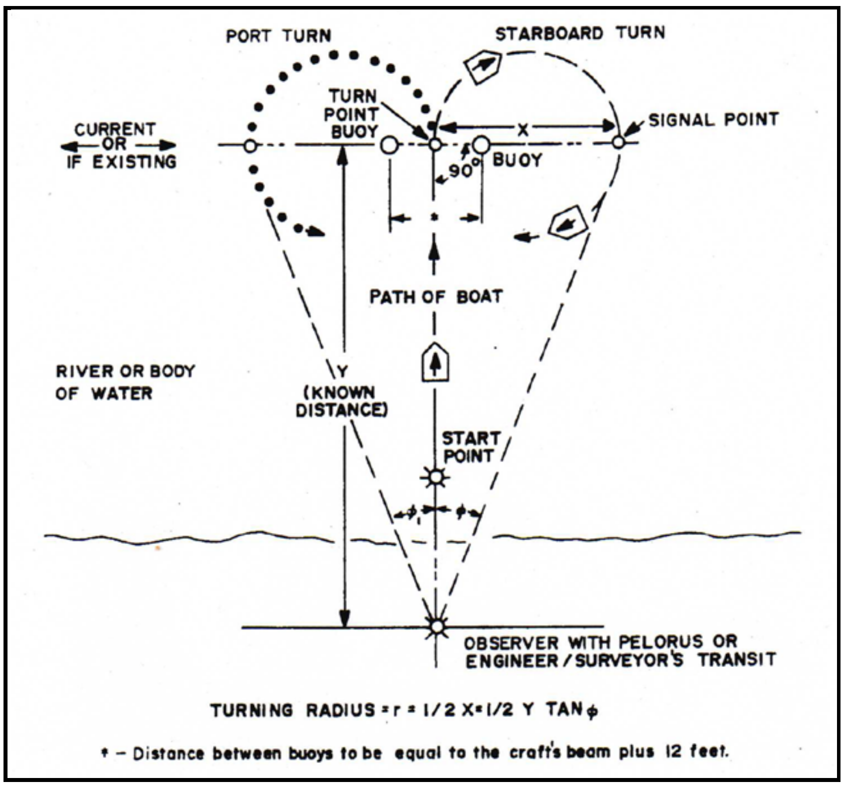


Figure 9. Turning radius determination.

b. The vessel is positioned at the start point, started, and moved at full speed along the path shown in Figure 9.

c. Upon reaching the turn point buoy, a sudden hard right rudder is immediately executed.

d. The vessel continues in a tight circle until it has turned a full 180 degrees and reached the signal point.

e. The observer notes and records the angle read between the starting path and the signal point. To pinpoint time, a signal may be transmitted from the vessel to the observer at the instant the two buoys are aligned, indicating the 180 degree point.

f. The vessel is repositioned at the starting point and proceeds to accomplish a port turn.

g. When required, the procedures are repeated with the vessel operating astern.

h. Turning radii are computed using the formula shown in Figure 9.

4.6.3.2.2 Data Required.

For each turn, data to be recorded include weather conditions (current, wind, and condition of water), engine rpm, times for executing turns, and angle from the observer's point.

4.6.3.2.3 Data Presentation.

Results of the turning radius tests will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events.

4.6.4 Towing Resistance.

4.6.4.1 Method.

a. The vessel is loaded or ballasted to its specified trim condition (as a minimum, conditions tested should include light and fully loaded). A single line is attached to the towing vessel to permit the insertion of a calibrated load cell to read the towing force. The line is long enough to minimize the effect of wake of the towing vessel.

b. The vessel is towed at slow, half, and full speeds, and the steady-state tension is read at each speed. Surge readings associated with the slacking and tightening of the towline should be discounted. Pileup of water at the bow and tendency of the vessel to drive are watched closely, and the speed is adjusted accordingly so as to not exceed safe limits.

4.6.4.2 Data Required.

The vessel condition of loading is recorded. Load cell force is read at each speed (engine revolutions per minute (rpm)). Water formation at the bow and wave formation at the sides are photographed where pertinent. Comments are made on indications of directional or pitch stability and trim angle at maximum towing speed.

4.6.4.3 Data Presentation.

Results of the towing resistance tests will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events.

4.6.5 Beaching.

4.6.5.1 Method.

a. The beaching site is selected to include the gradient, configuration, and surf conditions for which the craft is designed. The approach is surveyed to ensure freedom from damaging underwater obstacles.

b. Preliminary landings are made with the vessel in light condition and in minimum surf. All beaching is attempted with the craft heading perpendicular to the shoreline. Retraction is accomplished by reversal of the engines while observing the engine cooling temperatures.

c. Landings are made under various loading and surf conditions. Once the vessel lands, the ramp is lowered and the cargo discharged. Dry ramp landings are made where practical. Retraction is accomplished with engines alone when practical and by deballasting or use of stern anchor or tow as required.

4.6.5.2 Data Required.

Recorded data for each landing include wind direction and velocity, vessel heading and loading, surf and current conditions, approach speed, and retraction time. Beach gradient and description are recorded. Observation is made of ability to maintain course and achieve intended landing site, tendency to broach, adequacy of power and control during retractions, and effects of propeller or waterjet wash. Ramp angles and clearance for cargo egress are noted. Inspection is made for noticeable hull damage and adverse effects from vibration, impact, or overheating.

4.6.5.3 Data Presentation.

Results of the beaching tests will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events.

4.6.6 Ramp Operation (Landing Craft and Amphibians).

4.6.6.1 Method.

a. The ramp is checked for alignment before and after all tests. Seals are checked periodically for watertightness.

b. The ramp is cycled continuously from fully closed to fully open position for a one-hour period (or as specified by requirements) with periodic stops at partially open positions. All mechanisms are observed for proper functioning, including security of latching devices, ability of the brake to hold position without creep, and free motion of lines and pulleys. For hydraulic systems, maximum and steady- state pressures are recorded as well as oil temperatures at the start and end of tests.

c. The ramp is placed in a horizontal position and loaded statically to 200 percent of the ramp design hoist condition. This load is held for a minimum of three minutes.

4.6.6.2 Data Required.

Recorded data include times to lower and raise the ramp, hydraulic oil pressures and temperatures, weight of the static load, and comments as to response to controls, effectiveness of latching and braking, occurrence of leakage, and adequacy of alignment.

4.6.6.3 Data Presentation.

Results of the ramp operation tests will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events.

4.6.7 Operational Performance.

4.6.7.1 Method.

a. The vessel is operated under simulated mission conditions, including docking, anchoring, and transporting and discharging cargo, in various seaways and channels, and under various weather and sea conditions for the specified number of operational hours.

b. Tests of special machinery, such as winches, anchor engines, and cargo gear, are arranged as required to determine characteristics.

4.6.7.2 Data Required.

Data are recorded on vessel behavior and handling in seaways, congested areas, or limiting sea conditions. Also recorded are description of test environment, times vessel is operated, types of operations, and manner of performance.

4.6.7.3 Data Presentation.

Results of the operational performance tests will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events.

4.6.8 Logistics-Over-The-Shore (LOTS).

4.6.8.1 Method.

Testing, whether LOTS or expanded to include multiple Services (Joint Logistics Over-the-Shore (JLOTS)) will be performed in accordance with TOP 01-2-510[35].

4.6.8.2 Data Required.

Data are recorded to determine conformance of the test item(s) with the CPD or other criteria. Specifically, the ability of the test item to support the transfer of cargo, personnel, or equipment in the prescribed operational environment will be recorded. Vessel behavior and interoperability in sea conditions ranging from deep water through littoral environments will be recorded. Also recorded are description of test environment, vessel to vessel interface results, throughput efficiency, types of operations, and seakeeping performance.

4.6.8.3 Data Presentation.

Results of the LOTS tests will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events.

4.6.9 Communications, Electronic, and Navigation Equipment.

4.6.9.1 Method.

a. During inspection, the provision, compliance with regulatory requirements, and adequacy of installation of equipment are ensured.

b. Equipment is used for its intended purpose throughout operational tests. Navigation equipment is used during the various conditions encountered under day, night, and all-weather operation. Radio communication equipment is used to communicate with various shipboard, aircraft, and shore installations. Audible and visible signals are checked during these communications. Equipment is evaluated as required by the applicable specification.

c. Internal communication and control systems are checked during continuous service. All equipment is observed for adequacy of operating instructions, accessibility and ease of servicing, and performance during various operations. Equipment is evaluated as required by the applicable specification.

d. External hailing devices are checked during continuous service. All equipment is observed for adequacy of operating instructions, accessibility and ease of servicing, and performance during various operations. Speech intelligibility testing is conducted to ensure the message transmitted over the hailing system is clear enough for understanding. Equipment is evaluated as required by the applicable specification.

4.6.9.2 Data Required.

Recorded data reflect the adequacy of each individual system or equipment, extent of usage, limits or range of performance, and any instances of malfunctioning or unsuitability.

4.6.9.3 Data Presentation.

Results of the communications, electronic, and navigation equipment tests will be summarized in paragraph, chart, or tabular form and supplemented with photographs of specific test events.

4.6.10 Kits.

4.6.10.1 Method.

Various kits may be furnished and are tested separately in accordance with their intended function, such as firefighting, winterization, deckhouse conversion, lighting, etc. In general, test procedures include the assembly and installation, operational tests, and tests for endurance through a specified period of use.

4.6.10.2 Data Required.

Recorded data include the adequacy of instructions, times to assemble and install, adequacy of performance, and faults or difficulties experienced.

4.6.10.3 Data Presentation.

Results of the demonstration of the use of the employed kits to include the assembly, installation, and reliability during testing summarized in tabular form and supplemented with photographs of specific test events.

4.6.11 Inflatables.

4.6.11.1 Method.

a. Inflation/Deflation.

(1) The item is prepared for testing by checking the existence and proper assembly of the carbon dioxide (CO_2) cylinder, its valve, and the pull cable assembly. The item is folded and inserted, with associated accessories, into its container, and the loops of the pull cable are properly attached. The packaged item is placed horizontally in a clear area.

(2) The item is inflated by triggering the inflation device in accordance with instructions.

(3) The item is observed as it exists in its container and assumes its inflated configuration, and the pressure in each inflated compartment is measured after one hour.

(4) The item is inspected for any evidence of structural or material failure or weakness at seams, seals, or adhesive areas, and any twisting, distortion, or misfit of parts.

(5) The item is deflated, and any difficulty in gas discharge is noted.

b. Air Pressure.

(1) The item is placed horizontally, and the relief valves are capped to prevent operation.

(2) Each inflation compartment is inflated with dry air to an overpressure as specified in the requirements document, or to 5.0 psi in primary tubes and 2.0 psi in secondary tubes, if unspecified.

(3) After 10 minutes, the pressure in each compartment is checked and adjusted, if necessary, to the specified value. After an additional 10 minutes, pressures are read and recorded.

(4) Inspection is made for signs of construction or material weakness; separation in seams, seals, or adhesive attachments; twisting, distortion, or misfit of parts.

(5) When extended periods of testing are required, pressures are read after 24 hours or when specified. Ambient temperatures and pressures are recorded to permit conversion of findings to standard conditions for comparison.

(6) The item is deflated and inspected for puckering of seams or attachments.

c. Water Leakage.

(1) The inflated item is floated in calm water and loaded, leaving three inches of freeboard. Loading should simulate seated personnel and be distributed so that the item remains level while afloat.

(2) The item is allowed to remain floating for 24 hours, or the specified period, and is inspected periodically for leakage during this period.

4.6.11.2 Data Required.

a. Inflation. Recorded data include inflation time, adequacy of assembly and inflation instructions, inflation pressures, deflation time, and description of any malfunctions or inadequacies.

b. Pressure. Recorded data include pressures at the specified time intervals and identification of any leakage that occurs.

c. Leakage. Evidence of leakage, including location and amount, is recorded.

4.6.11.3 Data Presentation.

Results of the inflation time, adequacy of assembly and inflation instructions, inflation pressures, deflation time, and description of any malfunctions or inadequacies will be recorded in tabular form and supplemented with photographs of anomalies.

4.7 Environmental Effects.

a. Tests are based on the requirements of the CPD or other governing document. Environmental attributes are delineated in US Army Regulation (AR) 70-38[36]. Test procedures are detailed to suit the particular test item in accordance with the Detailed Test Plan (DTP) developed by the test agency. The size of the test item may allow chamber testing. Environmental chamber testing exhibits the optimal control of the requisite conditions; however, some extreme conditions applicable to waterway equipment occur only in a natural environment. Factoring in the costs and mission requirements involved, a coordinated test program may be appropriate, with testing conducted in a field environment site.

b. On-Site and Field Tests. For intermediate climatic conditions, the temperate zone locale of the assigned test agency may provide the required environment. For more extreme conditions, the environmental chamber test sites are used. For specific procedures for climatic testing, the following references should be consulted: TOP 02-2-650[37] (cold starting and warm-up), TOP 02-2-708[38] (personnel heating systems), and MIL-STD-810G.

c. Environmental Chamber/Facility Tests. Environmental chamber and facility tests are reserved for smaller vessels and component testing when advantageous from a time or cost-saving aspect. Vessels built using common materials may be evaluated via paper study comparing the construction materials with a database of known materials to determine factors such as resistance to fungal growth or decontamination ability. MIL-STD-810G outlines the setup and procedures required for the conduct of chamber and facility tests.

4.7.1 Low Temperature.

4.7.1.1 Method.

a. A pretest functional or operational check test will be conducted to provide a baseline. All nonfunctional components or subsystems should be repaired or recorded.

b. Storage. The test system and engine will be prepared for low temperature testing in accordance with the TM. The test item will be positioned in the climatic chamber in the stored configuration. The storage temperature requirements gleaned from the CPD or other requirements document will be followed. Storage testing will be performed in accordance with MIL-STD-810G, Test Method 502.5, Procedure I, for a minimum of two hours after temperature stabilization. The chamber temperature will be increased to ambient, the components and subsystems will be visually inspected, and the test item will be functionally checked. Results of the functional check will be compared with the pretest data.

c. Operation and Manipulation. MIL-STD-810G, Test Method 502.5, Procedure II, operation, will be conducted. After system stabilization at the low operating temperature, MIL-STD-810G, Procedure III, manipulation, will be performed. The test system will be operated in accordance with the TM. External supply of cooling water or other system requirement is allowed provided the characteristics of the externally supplied material are consistent with the expected naturally occurring conditions. Difficulties experienced by the test crew in operating or maintaining the system with cold weather gear to include boots, gloves, hoods, and clothing will be recorded. The test team will operate the test item long enough to ensure that all components and subsystems are fully functional and no leaks or other operational anomalies are experienced. If not specified in the CPD, the test item will be operated long enough for all gauges to stabilize. System operating data will be recorded at a rate to capture any short duration transients. After the operational test, the test item will be powered down in accordance with the TM. The chamber temperature will be increased to standard ambient. All subsystems and hardware will be visually inspected to determine whether any low temperature degradation or damage was experienced.

4.7.1.2 Data Required.

a. Test item identification.

b. Pretest functional check results.

c. Low temperature preparation or servicing.

d. Posttest low temperature storage visual inspection and functional test results.

e. Cold start procedures.

f. Chamber, test fluid, and system temperature time histories.

g. Test system operating data.

h. Malfunctions, deformation, or leakage during test item operation (TIRs).

i. Comments regarding the employment of cold weather gear.

4.7.1.3 Data Presentation.

System operating data will be presented in a table. Temperature time histories will be summarized in tables or presented as graphs. Inspection and operating results recorded in TIRs will be summarized in paragraphs or tables.

4.7.2 High Temperature.

4.7.2.1 Method.

a. A pretest functional or operational check test will be conducted to provide a baseline. All nonfunctional components or subsystems should be repaired or recorded.

b. Storage. The test system and engine will be prepared for high temperature testing in accordance with the TM. The test item will be positioned in the climatic chamber in the stored configuration. The storage temperature requirements gleaned from the CPD or other requirements document will be followed. Storage testing will be performed in accordance with MIL-STD-810G, Test Method 501.5, Procedure I, for a minimum of two hours after temperature stabilization. The chamber temperature will be decreased to ambient, the components and subsystems will be visually inspected, and the test item will be functionally checked. Results of the functional check will be compared with the pretest data.

c. Operation and Manipulation. MIL-STD-810G, Test Method 501.5, Procedure II, operation, will be conducted. After test item stabilization at the high operating temperature, the test item will be operated in accordance with the TM. External supply of cooling water or other system requirement is allowed provided the characteristics of the externally supplied material are consistent with the expected naturally occurring conditions. The test team will operate the test item long enough to ensure that all components and subsystems are fully functional and no leaks or other operational anomalies are experienced. If not specified in the CPD, the test item will be operated long enough for all gauges to stabilize. System operating data will be recorded at a rate to capture any short-duration transients. After the operational test, the test item will be powered down in accordance with the TM. The chamber temperature will be decreased to standard ambient. All subsystems and hardware will be visually inspected to determine whether any high temperature degradation or damage was experienced.

4.7.2.2 <u>Data Required</u>.

a. Test item identification.

b. Pretest functional check results.

c. High temperature preparation or servicing.

d. Posttest high temperature storage visual inspection results.

e. Chamber, test fluid, and pump temperature time histories.

f. Test system operating data.

g. Malfunctions, deformation, or leakage during system operation (TIRs).

4.7.2.3 <u>Data Presentation</u>.

System operating data will be presented in a table. Temperature time histories will be summarized in tables or presented in graphs. Inspection and operating results recorded in TIRs will be summarized in paragraphs or tables.

4.7.3 Humidity.

4.7.3.1 Method.

a. A pretest functional or operational check test will be conducted to provide a baseline. All nonfunctional components or subsystems should be repaired or recorded. The test item will be visually inspected, and any existing corrosion, delamination, or protective coating anomalies will be recorded and photographed.

b. The test item will be positioned in the climatic chamber in the operational configuration. Aggravated testing will be performed in accordance with MIL-STD-810G, Test Method 507.5, Procedure II. A 24-hour conditioning cycle will be performed, followed by a minimum of ten cycles of the aggravated test cycle. The test item will be subjected to an operational check after every five cycles. If not specified in the CPD or other performance specification, the system will be operated for a minimum of two hours. System operating data will be recorded at least hourly, but at a frequency rate high enough to capture any transient data.

c. After humidity exposure, the test item will be visually inspected. Any corrosion or material degradation will be recorded. A posttest functional or operational check test will be performed, and the results will be recorded.

4.7.3.2 Data Required.

a. Test item identification.

b. Pretest functional check results.

c. Pretest visual inspection results.

d. Chamber temperature and humidity time histories.

e. Test system operating data.

f. Malfunctions, deformation, or leakage during system operation (TIRs).

g. Posttest visual inspection results.

4.7.3.3 Data Presentation.

System operating data will be presented in a table. Temperature and humidity time histories will be summarized in tables or in a graph. Inspection and operating results recorded in TIRs will be summarized in paragraphs or tables. Corrosion will be classified in accordance with the US Army Tank-Automotive Command Life Cycle Management Command (TACOM LCMC) Corrosion Rating System[39].

4.7.4 Salt Fog.

Test sequence guidance is provided in MIL-STD-810G, Test Method 509.5, paragraph 2.1.2.

4.7.4.1 Method.

a. A pretest functional or operational check test will be conducted to provide a baseline. All nonfunctional components or subsystems should be repaired or recorded. The test item will be visually inspected, and any existing corrosion will be recorded and photographed.

b. The test item will be positioned in the salt fog chamber in the operational configuration. Testing will be performed in accordance with MIL-STD-810G, Test Method 509.5. After testing, the test item will be removed from the chamber, rinsed with water, and visually inspected. Any corrosion will be recorded and photographed.

c. After testing, a functional or operational check test will be performed, and the results will be recorded.

4.7.4.2 Data Required.

a. Test system identification.

b. Pretest functional check results.

c. Pretest visual inspection results.

d. Chamber temperature, salt-fog potential of hydrogen (pH), and fallout rate time histories.

e. Posttest visual inspection results.

f. Test system operating data.

g. Malfunctions, deformation, or leakage during system operation (TIRs).

4.7.4.3 Data Presentation.

System operating data will be presented in a table. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables. Corrosion will be classified in accordance with the TACOM LCMC Corrosion Rating System.

4.7.5 Fungus.

Test sequence guidance is provided in MIL-STD-810G, Test Method 508.6, paragraph 2.1.2. Recommend to the AST that the test system manufacturer develop a list of all component and subsystem materials. The materials should be compared with the fungus-inert and fungus

nutrient lists in MIL-STD-810G, Test Method 508.6, Annex B. Manufacturer-specific brand names should be researched to determine the common terminology or constituents. Materials listed on the fungus nutrient list that have been treated will require identification of the treatment method. Those materials not certified as fungus-inert, or are treated fungus nutrient materials, should be submitted for laboratory testing. Material samples can be submitted in lieu of the entire component (i.e., a 10- to 12-inch sample of hose material could be submitted in place of a 50-feet hose line).

4.7.5.1 Method.

a. Testing will be performed in accordance with MIL-STD-810G, Test Method 508.6. If the test duration is not included in the CPD or other performance specification, a minimum duration of 28 days (84 days - optimal) should be employed.

b. Immediately after testing, the test item(s) will be visually inspected, and the results will be recorded.

4.7.5.2 Data Required.

a. Test material and component identification and condition (new or used).

b. Pretest cleaning performed, if any.

c. Species of fungus grown and inoculated on the cotton control strips and test item material samples.

d. Chamber temperature and humidity time histories.

e. Test duration (days).

f. Posttest visual inspection and/or functional check results in accordance with MIL-STD-810G, Test Method 508.6.

g. Test system operating data, if applicable.

h. Malfunctions, deformation, or leakage during system operation (TIRs), if applicable.

4.7.5.3 Data Presentation.

The components and materials used during testing will be presented in a table. The test procedure and inspection results will be summarized in paragraphs or tables. System operating data will be presented in a table. Operating results documented in TIRs will be summarized in paragraphs or tables.

4.7.6 Blowing Rain.

MIL-STD-810G, Test Method 506.5, Procedure I, will be used as a general guide during testing of smaller test items. Procedure II will be used a general guide during testing of larger test items.

4.7.6.1 Method.

a. A pretest functional or operational check test will be conducted to provide a baseline. All nonfunctional components or subsystems should be repaired or recorded. All POL reservoirs will be sampled. Interior spaces should be dry to allow determination of water penetration.

b. The test item will be positioned at the Rain Test Facility or adjacent to a high pressure water source for use if Procedure II is employed. The test item will be placed in the operational configuration. If not specified in the CPD or other performance specification for the test item, the rainfall rate will be 1.7 millimeters per minute (mm/min) (4 in./hr), and the wind speed will be 18 meters per second (m/s) (40 mph). After each side of the test item is exposed to blowing rain, it will be inspected, and operating data will be recorded. All instruments and pressure/temperature/flow measuring devices will be inspected to determine whether they were degraded. Electrical control panels, if applicable, will be inspected for water intrusion. Fluid reservoirs (engine oil, fuel source) will be sampled before and after testing, and the samples will be submitted to a chemistry laboratory for water content analysis.

4.7.6.2 Data Required.

a. Test system identification and orientation.

b. Pretest functional check results.

c. Ambient temperature and wind speed.

d. Side of test system exposed and duration.

e. Rainfall rate and wind speed.

f. Posttest visual inspection results.

g. Test system operating data.

h. Lubricant and fuel source water analysis results.

i. Malfunctions, deformation, or leakage during system operation (TIRs).

4.7.6.3 Data Presentation.

System operating and test fuel data will be presented in a table. Inspection and operating results recorded in TIRs will be summarized in paragraphs or tables.

4.8 Electromagnetic Environmental Effects (E3).

4.8.1 Method.

a. As listed in TOPs 06-2-542[40] (electromagnetic interference (EMI)) and 01-2-511[41] (electromagnetic compatibility (EMC)), specific radiated and conducted emissions and susceptibility tests will be performed in accordance with the CPD, other performance specifications, and MIL-STD-461F for test items small enough to fit inside an anechoic chamber.

b. System operating data will be recorded during all tests that permit personnel in the chamber. Otherwise, the test item will be monitored remotely by cameras focused on the control panel or specific engine or system instruments to determine whether the system operation has been degraded.

c. For larger items, manufacturer's data from component level testing will be verified for compatibility during the dock trials phase of testing. High output transmission units such as radios, radar units, sonar, and fire control systems will be alternately energized and their effects on surrounding equipment noted. Electronically induced anomalies will be determined by inspection to include:

(1) Un-commanded movement of electronically controlled subsystems.

(2) Static heard over communication systems.

(3) Display distortion (radar screen, depth finders, etc.).

(4) Unexpected control panel light activation.

(5) Blown fuses or tripped circuit breakers.

d. Vessels required to operate in theaters of war, may be required to operate through or after a HEMP event. Component testing can be conducted at facilities designed for this purpose. Larger systems can be evaluated by analysis to determine if the component shielding is sufficient to prevent damage from a HEMP event.

e. Vessels are likely to encounter the naturally occurring effects of Near Strike Lighting (NSL) which can damage electrical components and pose risks to personnel. Proper bonding and grounding of vessel components can limit the adverse effects of NSL. Analysis of design and manufacturing techniques is utilized to determine if the vessel is resistance to NSL. Bonds and grounds will be tested in accordance with MIL-STD-1310H[42].

f. Radiation Hazard (RADHAZ) specifications contained in American National Standards Institute (ANSI)/IEEE C95.1-1992[43] to include Hazards to Personnel (HERP), Ordnance (HERO), and Fuel (HERF) is calculated by determining the physical location of transmitting antennae in relation to the potential susceptible item and factoring in the output strength of the transmitter.

4.8.2 Data Required.

a. As listed in TOP 06-2-542, TOP 01-2-511, MIL-STD-1310H, and ANSI/IEEE C95.1-1992.

b. System identification and test configuration.

c. Electronically induced anomalies.

d. Repairs or maintenance performed to restore the test item to a fully functional state, record in TIRs.

4.8.3 Data Presentation.

a. As listed in TOPs 06-2-542 and 01-2-511.

b. Test item operational or electronically induced anomaly data will be presented in a table. The inspection and operating results recorded in TIRs will be summarized in paragraphs or tables.

4.9 Human Factors Engineering (HFE).

4.9.1 Method.

Pursuant to the tenets of MIL-STD-1472, MIL-STD-1474D[44], and International Organization for Standardization (ISO) 2631-1[45], the vessel will be examined for adherence to the prescribed man/machine interface criteria therein. A stem to stern inspection will be performed and the results recorded to ensure the vessel can be operated by the required anthropomorphic-representative soldiers, in a variety of military apparel to include mission- oriented protective posture (MOPP) 4, arctic, and personal protective equipment (PPE) without unmitigated exposure to health risks.

4.9.2 Data Required.

a. Proper placement, size, and content of warning placards.

b. Warning lights, blackout lighting requirement adherence, and sightlines.

c. Noise (sound pressure levels) while operating and conducting maintenance.

d. Toxic fumes testing to determine exposure level to personnel.

e. Ability to operate switches, latches, handles, tools, control levers, etc., in all prescribed environmental conditions.

f. Weights of all portable equipment to include labeling stating the minimum personnel lift requirement.

g. Presence of any physical hazards (sharp edges, pinch points, shock hazards, etc.).

h. The effects of exposure to whole body vibration.

4.9.3 Data Presentation.

Results of testing will be presented in a test report. The test report will include the pass/fail criteria from MIL-STD-1472G, the procedures used to conduct the test, and the results of testing, including photographs of test setup and any damage. Findings will be summarized in paragraphs or tables with photographs for additional clarity.

4.10 Reliability and Durability.

a. Army Materiel Command Pamphlet (AMCP) 702-3[46] will be used as a general guide during testing.

b. The CPD or other performance specification documentation will list the threshold and objective levels of operational availability (A_o), mean time between failures (MTBF), and other reliability coefficients required by the test item. In system of systems architecture that includes redundant backup systems, the ability to determine the operational readiness of a system that is not operating optimally requires the evaluation of the ability of the overall system to meet the tenets of the concept of operations (CONOPS). For commercial off-the-shelf (COTS) equipment, each manufacturer states the reliability coefficient of a particular subsystem. The effects of maintenance intervals of subsystems and their impact on overall system readiness can be calculated. Because of the high operating cost of larger watercraft to garner the number of operating hours to validate the accuracy of reliability calculations, manufacturer's data from real world usage of similar subsystems is often used in lieu of actual testing.

4.10.1 Method.

a. Vehicle component failures, including maintenance-related components and systems, will be monitored throughout testing. Any malfunctions or problems encountered while performing maintenance tasks will be recorded. At the time of each malfunction, the failed component or assembly will be identified, and the accumulated operating time (miles and cycles) of the system and life (miles and cycles) of the failed component will be determined and recorded.

b. Incidents detected and maintenance actions performed during testing will be reviewed and scored at the formal scoring conference using the approved Failure Definition/Scoring Criteria (FD/SC). The scoring conference results will establish the failures to be charged for reliability computations and maintenance actions whose times are to be chargeable to the maintenance statistics.

c. The test item will be equipped with the necessary instrumentation, which may include the Advanced Distributed Modular Acquisition System (ADMAS), and/or Advanced On-Board Computer System (ADOCS). The ADOCS will have an ADOCS Signal Conditioning System (ASCS) and vehicle endurance performance analyzer (VEPA) to acquire analog data from sensors applied as required to record test data.

4.10.2 Data Required.

a. Test system identification and test configuration.

b. Pretest functional check results.

c. Pretest visual inspection results.

d. Posttest visual inspection results.

e. Repairs or maintenance performed to restore the test item to a fully functional state, record in TIRs.

4.10.3 Data Presentation.

System operating data will be presented in a table. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables.

4.11 Transportability.

4.11.1 Method.

a. The procedures for transportability testing are primarily applied to smaller vessels able to be shipped by rail, road, and as marine or air cargo. The shipping requirements are delineated into two functional areas: the ability of the item to be restrained and the resistance of the item to damage associated with the shipping process. TOPs 01-2-500[47] and 01-2-501[48] will be used as general guides during testing.

b. Tie-down configurations and subsequent securement to various shipping platforms is covered under the auspices of the Military Surface Deployment and Distribution Command - Transportation Engineering Agency (SDDCTEA) for road, rail, and marine transport. Internal transport in fixed wing aircraft falls under the auspices of the Air Transportability Test Loading Activity (ATTLA). Internal and helicopter sling load (HSL) transport using rotary wing aircraft is under the auspices of the US Army Natick Soldier Research, Development and Engineering Center (NSRDEC). Lifting and tie-down provisions will be tested in accordance with MIL-STD-209K[49] and the data forwarded to the requisite transportation authority.

c. The innate ability of road, rail, and air transported watercraft, with certified lift and tie-down provisions, to withstand the rigors of shipping is covered under the auspices of MIL-STD-810G. Testing falls into two principal categories: road shock and vibration (RS&V) and rail

impact. RS&V testing is used to determine whether vessels carried as cargo or as part of an integrated transport system can be loaded, transported, and unloaded over prescribed terrain types without vibration-related performance degradation. Rail impact testing is used to determine whether vessels being shipped via rail can remain secure to the rail car during transit and train car handling at rail head switching facilities, and can remain operationally viable upon reaching their destination. Internal air transport (IAT) and external air transport (EAT, alternatively designated as HSL) testing is used to provide the data required to obtain Transportability Certifications from approval authorities and are covered in MIL-HDBK-1791 (IAT) and MIL-STD-913A (EAT).

4.11.2 Data Required.

a. As listed in MIL-STD-810G, MIL-HDBK-1791, MIL-STD-209K, and MIL-STD-913A.

b. Pretest functional check results.

c. System transport methods and terrain requirements for road transport.

d. Lift or tie-down provision failure as defined in MIL-STD-209K.

e. Operational readiness after RS&V, rail impact, and EAT (if applicable).

f. Type and time to complete any repairs, maintenance, or reconfiguration required to prepare the system for, and return the system to, operational readiness before or after transport.

4.11.3 Data Presentation.

Results of testing will be presented in a formal test report. The test report will include the pass/fail criteria, the procedures used to conduct the test, and the results of the test to include photographs of test setup and any damage. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables.

4.12 Integrated Logistics Support (ILS).

Logistics support encompasses the ability of the end unit item to operate over its lifecycle with proper provisioning (i.e., TMs, adequate spare parts, adequate support, and test equipment) and how well the end unit item adheres to good maintainability practices.

4.12.1 Method.

a. The equipment publications in the system support package (SSP) will be reviewed and evaluated to ensure accuracy, consistent nomenclature, and readily understandable instructions for scheduled and unscheduled maintenance.

b. Repair parts will be evaluated and recorded during repair/maintenance actions to ensure adequate quantities and diversity at the appropriate levels consistent with the maintenance allocation chart (MAC), Repair Parts Special Tools List (RPSTL), and skills required to install and align the parts. Repair parts used to maintain the system will be evaluated, to the extent possible, with regard to their interchangeability with like parts being replaced and their frequency of failure.

c. The vessel will be evaluated for the use of common tools rather than special tools. Any complicated test equipment requiring frequent calibration and restrictive environmental control conditions will be noted.

d. The vessel will be evaluated to determine whether the design eliminates deficiencies prejudicial to ease of maintenance by using reliable components, modular construction, built-in simple fault isolation test indicators, and other technological advances in components and methods to the maximum extent practicable.

4.12.2 Data Required.

a. For each maintenance action, the adequacy of the TM, any parts used, the total number of man-hours to complete the maintenance, the failure mode of the replaced item, and the total number of hours the replaced item was in service will be recorded.

b. The nomenclature of any replaced parts, the maintenance level that performed the maintenance (Field or Sustainment), reason for replacement, any difficulties with the replacement (alignment, installation, interchangeability), and tools required (including special tools).

4.12.3 Data Presentation.

The data will be presented in a test report containing text, tables, augmenting photographs, and data analysis.

4.13 Survivability.

The ability to assess the vulnerability and/or anti-terrorism force protection (AT/FP) of a vessel requires the comparison of a threat assessment with the design characteristics of the craft. The complexities of emerging threats and the high cost of vessels make live fire demonstrations cost prohibitive; therefore, the most common practice is an evaluative paper study augmented by coupon testing of vessel materials. Survivability in paragraph 4.13 will consider only ballistic survivability and AT/FP criteria. Seakeeping in paragraph 2.5 addresses the non-ballistic survivability of the vessel.

4.13.1 Method.

a. Testing to address the ability of the vessel structure and onboard equipment to withstand the effects of large shocks caused by underwater explosions will be conducted

pursuant to the tenets of Military Specification (MIL-S)-901D[50] at an Underwater Explosion Facility (UNDEX). Small components can be tested in certified test laboratories.

b. Coupon testing matches the vessel material (e.g., hull plating) against an expected threat (e.g., rocket-propelled grenade (RPG)) to determine the effectiveness of the material. Angles of attack range from threat to target, and environmental conditions are taken into account to provide the most realistic scenario.

c. HEMP is of primary concern to sensitive electronics and is covered in EMI (paragraph 4.8).

d. AT/FP compares the CONOPS of the vessel with the threats likely to be encountered in that environment and under the sea conditions that could be present during any engagements. Defensive strategies vary to include speed to elude, defensive weaponry, multispectral chaff, and ballistic protective materials.

4.13.2 Data Required.

a. CONOPS of the vessel and subsequent threat assessment to develop live fire scenarios (if required).

b. Vessel construction materials list to determine via paper study whether the material is overmatched for the threat and, as such, testing is moot.

c. Defensive system and damage control equipment (both automatic and manual).

4.13.3 Data Presentation.

The data will be presented as a paper study evaluation or results report based on the threat assessment, vessel materials/design, CONOPS, and results of live fire coupon testing, if conducted. The report will contain text, tabular, and graphical representations of the data.

4.14 Decontamination.

The ability of a vessel to be decontaminated to the extent that Soldiers are not placed in contact with contaminates and for the vessel to survive the decontamination process is a critical determination of the overall vessel design.

4.14.1 Method.

a. A vessel materials list is compared with a decontamination database to determine the ability to meet the decontamination criteria.

b. The design characteristics of the vessel is examined. For example, a craft with fewer nooks, crevices, cupped depressions (e.g., cloverleaves), is easier to decontaminate than one with a preponderance of places where contaminates may not be easily flushed.

c. The presence of a chemical wash down system designed to greatly enhance the decontamination process preventing contaminates from adhering to the vessel surfaces is recorded.

4.14.2 Data Required.

a. Vessel materials list to include any items that could be exposed to airborne or seaborne contaminates.

b. Record of the vessel exterior structure to determine the ability of contaminates to be flushed completely from the vessel. Smaller craft with open areas are typically poor candidates for decontamination.

c. Record of observation of the coverage of a chemical wash down system (if installed). Determination of whether the water runs off the vessel or pools in areas.

d. If actual administration of a tracking substance is applied to a vessel and subsequently decontaminated, record the following: type of tracking material used, employment of and duration of a chemical wash down system, results after decontamination, and any damage to the vessel after decontamination.

4.14.3 Data Presentation.

Decontamination studies are typically analytical in nature, using an existing database of materials and their decontamination properties. The data will be presented in text, tabular, and chart format with any anomalies captured using photographs.

4.15 Final Inspection.

4.15.1 Method.

After testing, the vessel is visually inspected and functionally checked. A summary of any damage or deterioration sustained and recommended corrective actions will be recorded and photographed. Any corrosion or material degradation will be noted and photographed. The corrosion will be rated in accordance with the TACOM LCMC Corrosion Rating System.

4.15.2 Data Required.

a. Physical inspection and operational tests results.

b. Damage, deterioration, and corrosion photographs.

c. Corrective actions performed to remedy the defects.

4.15.3 Data Presentation.

Results of the final condition/readiness of the test item, affected repairs, or system modifications will be recorded in tabular form and supplemented with photographs. Corrosion inspection results will include all corrosion related damage or deterioration and associated repairs or other corrective actions and be classified in accordance with the TACOM LCMC Corrosion Rating System.

4.16 Production Verification Testing (PVT).

4.16.1 Method.

Production verification testing, as required by AR 70-1,[51] consists of specification tests to determine whether the item conforms to its procurement document and suitability tests as prescribed by the test directive to determine whether the item is suitable for issue. The Test & Evaluation Working-level Integrated Product Team (T&E WIPT) is formed by the AST chair to manage the testing and subsequent evaluation of the required specifications. Test data from the T&E WIPT validated sources can include manufacturer or Government data from preproduction tests (including trials agenda on items procured by the other branches of the military) and can reduce the scope of further testing insofar as is practicable. The release of materiel to the service requesting testing is done in accordance with the guidelines established in US Army Materiel Command Regulation (AMCR) 700-34[52].

4.16.2 Data Required.

a. The data required encompasses the results of the tests in paragraphs 4.1 through 4.15.

b. Data will support assessments/evaluations for:

(1) Condition at the start of testing.

(2) Effectiveness of NET.

(3) Physical characteristics.

(4) Safety/human factors engineering (HFE).

(5) Performance.

(a) Seakeeping.

(b) Integration/compatibility.

(c) Transportability.

(d) Environmental.

(e) Subsystems.

(6) Survivability.

(7) Posttest condition of vessel.

c. The data from the PVT will support the full-rate production (FRP) decision, the Safety Release (SR) required for Soldier participated events such as: Logistic Demonstration (Log Demo) and operational test and evaluation (OT&E), and the Safety Confirmation (SC) to support the Acquisition Milestone Decision.

4.16.3 Data Presentation.

Results of the PVTs will be summarized in a formal test report, pursuant to ATEC guidelines, that will include data in paragraph, chart, or tabular form, supplemented with photographs of specific test events, and will contain an evaluation of the degree to which the requirements were met.

5. DATA REQUIRED.

Data required are listed throughout Section 4: Test Procedures.

6. PRESENTATION OF DATA.

Data presentation is listed throughout Section 4: Test Procedures. Sample data forms are also provided in Appendix B.

7. SUPPLEMENTAL INSTRUCTIONS.

a. Test Planning. Engineering test planning requires review of test guidance literature, familiarization with preceding development and test phases, study of test criteria, and selection of appropriate samples, methods, sequence, facilities, and test equipment. Standards for the test phases outlined in this section are given in the applicable PD or test directive as indicated in paragraph 1. Risk/cost and safety provisions must be given prime consideration. Data from previous and similar tests should be leveraged to the extent possible. Data from previous and similar tests should be considered in order to avoid duplication and reduce the scope of further testing. TOP 01-1-045[53], should be referred to as a background document.

b. Leverage of Existing Data. Some marine items are procured for the Army by the Navy, who conducts certain trials and acceptance tests prior to delivery to the Army. Such tests should be observed and findings considered in planning further tests.

c. Preparation for Test. Test preparations include the selection of appropriate test facilities, logistical support, review of the SAR, and selection and training of the test team, and need for NET. Adequate lead time should be planned commensurate with system complexity.

d. Familiarization and Training. Members of the test team may participate in NET to ensure they garner the requisite test item operational familiarity and boat handling capability to

include cognizance of the hazards of marine environments. For vessels requiring crew licensing in accordance with regulatory requirements, valid certification will be ensured by the responsible Test Officer. The test team will conduct practice drills and trials as necessary to ensure crew proficiency.

e. Inspection. The initial inspection is conducted in a sequence that will ensure that data, photographs, and damage assessment are obtained on the equipment as initially delivered, transported, crated or cradled, and followed by inventory, technical inspection, assembly, and functional checkout, as appropriate (see Appendix A for general inspection procedure guidelines). Care is taken to obtain dimensions, weights, cubages, and component data required before unpacking or assembly. During the detailed inventory and inspection, note should be made of the use of standard components and accessories as may be required by the PD. Adequacy of the technical literature provided for training and servicing on receipt should be noted.

f. Safety Evaluation. The safety subtest takes cognizance of the scope of marine operations and ensures the incorporation of applicable marine safety provisions, including the conduct of firefighting and lifeboat drills, use of an accompanying safety boat when applicable, and particular emphasis on communications during at-sea and night operations. Reference is made, as necessary, to such guidance as US Coast Guard regulations, SOLAS, and applicable safety directives.

g. Environmental Tests. Tests are based on the requirements of the PD or other governing document. For criteria and conditions of environment, AR-70-38 (and MIL-HDBK-310[54] for certain marine environments) is consulted. Test procedures are detailed to suit the particular test item. Depending on the size of the item, tests may include on-site and chamber testing. Cognizance is taken of the fact that some extreme conditions applicable to waterway equipment occur only in a natural environment and that with consideration of the costs and mission requirements involved, a coordinated test program may be appropriate, with tests conducted at the field environmental test site.

(1) On-Site and Field Tests. For intermediate climatic conditions, the temperature zone locale of the assigned test agency may provide the required environment. For more extreme conditions, the environmental test sites are used. For specific procedures, the applicable portions of the following references should be consulted: TOP 02-2-650, TOP 02-2-708, and MIL-STD-810G (Appendix A).

(2) Chamber Tests. Environmental chamber tests are entirely applicable to small items, such as inflatable boats, and are used when advantageous from a time or cost aspect. Following are references for specific procedures: TOP 02-2-815[55] (rain) and MIL-STD-810G.

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APPENDIX A. INSPECTION PROCEDURES.

A.1 For larger vessels, seaworthiness will be determined by the assigned classification society such as ABS or DNV. The Government-witnessed contractor testing and demonstrations will validate the adherence to the requisite time-tested naval engineering principles for oceangoing craft. Materials and welding, subsystems and components, crew habitability, evaluation of novel concepts, and risk measurement and mitigation designs are covered during the process of placing a vessel “under class”.

A.2 Regardless of the size of the vessel, developmental testing will ensure that the vessel is safe, suitable, and effective. Upon arrival for PVT, a preoperational inspection, assembly, and functional check is performed to ensure that the test item is safe, operable, and otherwise ready for testing and to verify that weights, dimensions, and similar characteristics conform to the technical literature.

A.3 The PS delineates the design and performance requirements. It is used to develop the test methodology as outlined in the DTP, by which all testing will be accomplished. Examples of the steps that may be involved for some types of waterway equipment are provided in this Appendix. It should be noted that operation of the vessel is done after completion of NET and can be accomplished with the assistance of a Field Service Representative (FSR) supplied by the manufacturer.

a. Literature. Review the draft technical manual(s), COTS manual, and/or other instructional material furnished with the test item. Throughout the inspection, observe the procedures and precautions listed therein, keeping a record of any inadequacies in the instructions.

b. Condition on Arrival. Before the packaging is removed, obtain dimensions, weights, cubages, and component data and compare with list received. Remove preservatives and protective material, and note any damage observed. Obtain dimensions and weights of components without packaging.

c. Assembly and Inspection. Assemble and install components and accessories, and ensure that the craft is complete in all respects. Obtain characteristics photographs to denote the condition of the test item, its attachments, or accessories that constitutes a potential hazard to personnel, the test item, or the test facilities, and proceed as follows:

(1) Engine and Engine Accessories.

(a) Check thoroughly for physical damage and loose parts and connections.

(b) When possible, crank the engine by hand to make sure all moving parts operate freely. Repeat with the shaft lever alternately in neutral, forward, and reverse.

(2) Fuel System. Check for physical damage and loose connections.

APPENDIX A. INSPECTION PROCEDURES.

(3) Cooling System.

(a) Check the inboard components of the engine and exhaust cooling systems for physical damage and loose hose connections.

(b) Check the heat exchangers for physical damage, secure mounting to hull, and ensure tightness of through-hull connections and drain plugs.

(4) Propulsion System.

(a) Check for physical damage to the coupling shaft log, shaft, strut, and propeller.

(b) Check for tightness of propeller on the shaft and locknut on the shaft nut.

(c) With the shaft lever in neutral, rotate the propeller by hand, and check for binding and misalignment. The propeller should turn freely.

(d) Check the shaft coupling to be sure that keys are in place and bolts are tight.

(e) Check the shaft log hose clamps for tightness.

(5) Steering System.

(a) Check for physical damage to the wheel, gearboxes, quadrant, and linkage.

(b) Check for loose mounting of components and loose setscrews.

(c) Swing the wheel through its complete range while an observer checks for corresponding free movement of the underwater steering mechanism.

(d) With the shift lever in neutral, carry the above check further by hand rotation of the propeller as the wheel is slowly moved from “hard aport” to “hard starboard” (this test will establish proper clearance between propeller blades and the steering mechanism).

(6) Controls and Control Stand.

(a) Check all controls to see that they are not broken or jammed.

(b) Manipulate all mechanical controls, and check for proper operation and tight connection of linkages.

(c) Manipulate all switches and place them in OFF position.

APPENDIX A. INSPECTION PROCEDURES.

(d) Check the stand and all controls and instruments for physical damage and loss of parts.

(7) Boat Electrical System and Electrical Accessories.

(a) Check the bow navigational light, stern navigational light, other running lights (as applicable), searchlight, floodlight, electric pump (s), blower (s), horn, and battery for physical damage.

(b) Check wiring for physical damage and loose connections.

(c) After servicing the battery, test all lights and electrical accessories.

(8) Hull. The following inspections should be performed:

(a) Carefully inspect the hull of the boat for loose or broken rivets, dents, punctures of the plating, chafing, or other physical damage. Check the areas that were in contact with the shipping container during transit.

(b) Check the hull for warpage.

(c) Check the skeg and other underwater gear for physical damage and misalignment.

(9) Fittings and Attachments. Inspect the deck hardware, hatch covers, towing bitt, and hull connectors for signs of damage.

(10) Auxiliary Equipment. Ensure that the craft is equipped with the required life preservers, oars, tools, repair parts, kits, lines, anchors, boathook, firefighting equipment, and other items specified for use with the boat.

(11) Plates. Record the presence and adequacy of nameplates, warning plates, and instruction plates.

d. Launching, Service, and Maintenance. Before operating the craft, perform the following:

(1) Perform all prelaunching maintenance and service procedures as set forth in the draft TM(s).

(2) Launch the craft in accordance with instructions furnished with the craft.

(3) When the test item consists of two sections, join the sections indicated in the furnished instructions.

APPENDIX A. INSPECTION PROCEDURES.

(4) Accomplish all post-launching maintenance and service procedures specified.

(5) Record the completion of each of the above tasks, any difficulties encountered, and any leakage of water into the craft.

e. Operational and Functional Check. Ensure that the craft is operational, and perform the following:

(1) Make the boat fast to dock or pier.

(2) Check the alignment of the transmission flange coupling and the propeller shaft couplings with a feeler gauge. Refer to the draft TM(s) for appropriate procedure.

(3) Bleed the propeller shaft seals to remove entrapped air.

(4) Ensure that all operating fluids are at their recommended levels.

(5) Check to ensure that the vessel is positioned in water of adequate depth to allow unrestricted operation and that the propellers are not fouled by line or debris.

(6) Start the engine(s) according to the procedures recommended in the instructional material. Allow the engine(s) to operate at idle speed.

(7) While the engines are warming up, check the engine instruments, electric bilge pump(s), and vessel lighting.

(8) Load the boat to obtain the maximum allowable draft as established by the draft TM(s). The weight should be loaded evenly about the vessel's CG to avoid a condition of undesirable list or trim.

(9) Visually inspect the craft for any condition of leakage.

(10) After the engine has been warmed up and temperature readings are stable, place the shift lever in the forward operating position and increase the engine speed to 2000 rpm (or as otherwise specified by the draft TM(s) or appropriate component specifications).

(11) Allow the engine to operate for one hour, during which the operator monitors all engine indicators and ensures that temperatures and pressures are within the specified safe operating ranges. At the end of the one-hour run, inspect the following for any leaks, faults, malfunctions, or failures:

(a) Engine cooling system.

APPENDIX A. INSPECTION PROCEDURES.

(b) Fuel systems.

(c) Lubrication systems.

(d) Belts or other drive arrangements.

(e) Hull seams and hull openings, including shaft logs, rudder shafts, propeller shaft seals, and exhaust outlets.

(12) During the final five minutes of operation, check the engine oil temperatures and coolant temperatures.

(13) Reduce the engine speed and verify astern operation by placing the shift lever in the astern operating position and increasing the engine speed to 1500 rpm (or as otherwise specified by the draft TM(s)). Allow the engine to operate for 30 minutes, and then secure the engine.

(14) Remove the weight previously added to the craft.

(15) Record the following:

(a) Any misalignment in shafting and the measures taken to eliminate the condition.

(b) Satisfactory operation of the electric bilge pump, blower, and boat lighting system.

(c) Any difficulties encountered in starting the craft's engine(s).

(d) Amount of weight added and the draft obtained (record draft forward and aft).

(e) Any leakage of water into the craft.

(f) Lube oil temperature at the end of the one-hour operating period.

(g) Cooling system temperature at the end of the one-hour operating period.

(h) Any excessive vibration or noise.

(i) Satisfactory operation ahead and astern.

(j) Any fault, malfunction, failure, or discrepancy observed.

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APPENDIX B. TEST DATA FORMS.

FORM B-1. TEST PARTICIPANT DEMOGRAPHIC DATA

Date: ________________

Name: ______________________________________

Birth Date: ____________________

Age (years/months): _______________

Military Rank: _____________ Civilian Job Description: ___________________

Years of Military Service: _________ Years of Civilian Service: ______________

Military Occupational Specialty (MOS) (number and description): ______________________

Time in service at current MOS: ____________________________________

Is this a primary or secondary MOS (circle one)? PRIMARY /SECONDARY

List the training you have completed in pump or other fluid delivery equipment: __________

____

____

____

List the experience you have had with pump or other fluid delivery equipment (identify systems):

____

____

____

APPENDIX B. TEST DATA FORMS.

FORM B-2. NET QUESTIONNAIRE

Evaluated By (Name): ______________________________ Date: ________________________
(First) (M.I.) (Last) (Day) (Mo) (Yr)

Rank/Grade: _______ MOS/Job Title: _____________ Experience: __________________
(Yr) - (Mo)

Related Training: ____
____

Related Experience: ____
____

Instructions: Circle a number between the adjectives which best represents your opinion of the instruction you have received during this training period.

A. Instructor(s):

1.	Used jargon or confusing terms	Never	1	2	3	4	5	6	7	8	9	Always
2.	Speaking ability (enunciation, volume, etc.)	Poor	1	2	3	4	5	6	7	8	9	Excellent
3.	Subject knowledge	Poor	1	2	3	4	5	6	7	8	9	Excellent
4.	Treatment of students	Discourteous	1	2	3	4	5	6	7	8	9	Courteous
5.	Aware of student understanding	Never	1	2	3	4	5	6	7	8	9	Always
6.	Preparation of instruction	Poor	1	2	3	4	5	6	7	8	9	Excellent
7.	Response to student questions	Poor	1	2	3	4	5	6	7	8	9	Excellent
8.	Overall rating	Unsatisfactory	1	2	3	4	5	6	7	8	9	Outstanding

B. Instruction:

1.	Basic concepts were defined at the beginning of each block of instruction	Never	1	2	3	4	5	6	7	8	9	Always
2.	Basic concepts were developed logically	Never	1	2	3	4	5	6	7	8	9	Always
3.	Presentation of material was	Boring	1	2	3	4	5	6	7	8	9	Interesting
4.	Classroom discussions were	Waste of time	1	2	3	4	5	6	7	8	9	Valuable
5.	Material was presented	Too slowly	1	2	3	4	5	6	7	8	9	Too rapidly
6.	Coverage of material was	Too basic	1	2	3	4	5	6	7	8	9	Too technical
7.	Training slides/presentation quality was	Poor	1	2	3	4	5	6	7	8	9	Excellent
8.	Training aids were used	Too seldom	1	2	3	4	5	6	7	8	9	Too often
9.	Lectures led into practical exercises	Never	1	2	3	4	5	6	7	8	9	Always

APPENDIX B. TEST DATA FORMS.

FORM B-2. CONTINUED

C. Practical Exercises or Hands-On Equipment Experiences:

1.	Time scheduled for PE was	Inadequate	1	2	3	4	5	6	7	8	9	Adequate
2.	PEs were conducted on actual hardware	Never	1	2	3	4	5	6	7	8	9	Always
3.	All students participated in PEs	Never	1	2	3	4	5	6	7	8	9	Always
4.	PEs were conducted as scheduled	Never	1	2	3	4	5	6	7	8	9	Always
5.	What percentage of the instruction time was "hands on" for you?		10	20	30	40	50	60	70	80	90	

D. Lesson Assignments and References:

1.	Assignments were necessary	Never	1	2	3	4	5	6	7	8	9	Always
2.	Assignments were	Too simple	1	2	3	4	5	6	7	8	9	Too difficult
3.	Manuals and reference materials were	Too elementary	1	2	3	4	5	6	7	8	9	Too complicated
4.	Manuals and reference materials were designed for easy use	Never	1	2	3	4	5	6	7	8	9	Always

E. Examinations:

1.	Material covered in exams was presented during instruction/PE	Never	1	2	3	4	5	6	7	8	9	Always
2.	Exams were	Too short	1	2	3	4	5	6	7	8	9	Too long
3.	Exams were	Too simple	1	2	3	4	5	6	7	8	9	Too difficult
4.	Performance-type exams were given	Never	1	2	3	4	5	6	7	8	9	Always
5.	Exams tested knowledge of material presented during instruction/PE	Not at all	1	2	3	4	5	6	7	8	9	Completely

Please make any comments you desire. Suggested areas for comment are superior or unsatisfactory instruction, missing elements of instruction, questions you still have concerning system operation or maintenance but are not comfortable asking in a classroom setting, or recommended deletions to course content.

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APPENDIX C. GLOSSARY.

Term	Definition
Amidships	A point halfway between the stem and stern.
Anchor	A heavy forging or casting shaped so as to grip the sea bottom and by means of a cable or rope, hold a ship or other floating structure in a desired position regardless of wind and current.
Athwartship	Across the ship, at right angles to the fore and aft centerline.
Ballast	Any solid or liquid weight placed in a ship to increase the draft, change the trim, or regulate the stability.
Ballast tank	A watertight enclosure that may be used to carry water ballast.
Bilge	Intersection of bottom and side. May be rounded or angular as in a chine-form hull. The lower parts of holds, tanks, and machinery spaces where bilge water may accumulate.
Bitt, mooring	Short metal column (usually in pairs) extending up from a baseplate attached to the deck for the purpose of securing and belaying ropes, hawsers.
Bollard	Similar in function to a bitt; however, this structure is usually located pier side and is used when berthing vessels. Typically is in the shape of an inverted teardrop with protrusions near the base to assist in securing lines.
Bulkhead	A term applied to the vertical partition walls that divide the interior of a ship into compartments.
Catamaran	A boat with twin side-by-side hulls.
Centerline	The middle line of the ship, extending from stem to stern at any level.
Cleat	A fitting having two arms or horns around which ropes may be made fast.
Deadweight	The carrying capacity of a ship at any draft and water density. Includes weight of cargo, dunnage, fuel, lubricating oil, fresh water in tanks, stores, passengers and baggage, and the crew and their effects.
Deck	A platform in a ship corresponding to a floor in a building.
Displacement	The weight of water that would be displaced by the column of the hull measured on the outer surface of the shell plating below the waterline.

APPENDIX C. GLOSSARY.

Term	Definition
Draft	The depth of the ship below the waterline measured vertically to the lowest part of the hull, propellers, or other reference point.
Dunnage	Cushioning, loose material placed under or among cargo in the holds to prevent cargo motion or chafing.
Dynamic stability	The ability of a body to remain upright when subjected to various external disturbing influences.
Fender	The term applied to devices built into or hung over the side of a vessel to prevent the hull from contacting other ships or piers.
Flange	The part of a plate or shape bent at right angles to the main part.
Forward	In the direction of the stem.
Freeboard	The distance from the waterline to the upper surface of the freeboard deck at side.
Heel	The inclination of a ship to one side.
Holds	Spaces below deck for the stowage of cargo; the lowermost cargo compartments.
Hull	The structural body of a ship, including the shell plating, framing deck, deck, bulkheads, etc.
Keel	The principle fore-and-aft component of a ship’s framing located along the centerline of the bottom and connected to the stem and stern frames.
Knot	Unit of speed equaling one nautical mile per hour (6076.1ft/hr).
List	If the centerline plane is not vertical; usually caused by more weight on one of the vessel, it is said to list or heel.
Metacenter	The center of buoyancy of a listed ship is not on the vertical centerline plane. The intersection of a vertical line drawn through the center of buoyancy of a slightly listed vessel intersects the centerline plane at a point called the Metacenter.
Metacentric height	The distance from the Metacenter to the center of gravity of a ship.

APPENDIX C. GLOSSARY.

Term	Definition
Pelorus	A device for measuring in degrees, the relative bearings of observed objects.
Skeg	A deep, vertical, finlike projection on the bottom of a vessel to minimize rolling or yawing.
Stability	The tendency of a ship to remain upright or the ability to return to the normal upright position when heeled by the action of waves, wind, etc.
Stem	The bow frame forming the intersection of the forwardmost sides of the ship, which is attached to the keel at the bottom and moves vertically upward from that point.
Stern	Aft-most part of the ship.
Transom	Vertical hull section at the stern to which outboard motors are attached or which forms the aft-most compartment of a non-outboard vessel.
Trim	The difference between the draft forward and the draft aft.
Ullage	The amount which the contents fall short of filling a container.
Wake	The body of water that tends to follow a ship. It is set in motion by the friction with the hull.

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APPENDIX D. ABBREVIATIONS.

A_o	operational availability
ABS	American Bureau of Shipping
ABL	above base line
ADMAS	Advanced Distributed Modular Acquisition System
ADOCS	Advanced On-Board Computer System
AMCP	Army Materiel Command Pamphlet
AMCR	US Army Materiel Command Regulation
ANSI	American National Standards Institute
APG	Aberdeen Proving Ground
AR	Army Regulation
ASCS	ADOCS Signal Conditioning System
AST	ATEC Systems Team
ASTM	American Society for Testing and Materials
AT/FP	anti-terrorism/force protection
ATC	US Army Aberdeen Test Center
ATEC	US Army Test and Evaluation Command
ATTLA	Air Transportability Test Loading Activity
BEB	bridge erection boat
BII	basic issue item
C	Celsius
CDD	Capabilities Development Document
CFR	Code of Federal Regulations
CG	center of gravity
cm	centimeter
CO_2	carbon dioxide
COMDTINST	Commandant Instructions
CONOPS	concept of operations
COTS	commercial off-the-shelf
CPD	Capabilities Production Document
DA	Department of the Army
DNV	Det Norske Veritas
DoD	Department of Defense
DTIC	Defense Technical Information Center
DTP	Detailed Test Plan
E3	electromagnetic environmental effects
EAT	external air transport
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EMITF	Electromagnetic Interference Test Facility
EMP	electromagnetic pulse

APPENDIX D. ABBREVIATIONS.

F	Fahrenheit
FAT	First Article Test
FD/SC	Failure Definition/Scoring Criteria
FED-STD	Federal Standard
FM	Field Manual
FRP	full-rate production
FSR	Field Service Representative
ft	feet
GHS	General Hydrostatic Software
GHz	Gigahertz
GM	Metacentric Height
HEMP	high-altitude electromagnetic pulse
HERF	Hazards of Electromagnetic Radiation to Fuel
HERO	Hazards of Electromagnetic Radiation to Ordnance
HERP	Hazards of Electromagnetic Radiation to Personnel
HFE	human factors engineering
HSL	helicopter sling load
IAT	internal air transport
ICD	Initial Capabilities Document
IEEE	Institute of Electrical and Electronics Engineers
ILS	Integrated Logistics Support
in.	inch
IPT	Integrated Product Team
ISO	International Organization for Standardization
JHA	Job Hazard Analysis
JLOTS	Joint Logistics Over-The-Shore
kHz	kilohertz
km	kilometer
km/hr	kilometer per hour
kt	knot
lb	pound
LCG	Longitudinal Center of Gravity
LogDemo	Logistics Demonstration
LOTS	Logistics-Over-The-Shore
LWE	Littoral Warfare Environment

APPENDIX D. ABBREVIATIONS.

m	meter
MAC	maintenance allocation chart
MATDEV	Materiel Developer
MHE	material-handling equipment
mi	mile
MIL-HDBK	Military Handbook
MIL-STD	Military Standard
mm	millimeter
MOPP	mission-oriented protective posture
MOS	military occupational specialty
mph	mile per hour
MSDS	Material Safety Data Sheet
MTBF	mean time between failures
NAVSEA	Naval Sea Systems Command
NET	new equipment training
NSL	Near Strike Lightning
NSRDEC	US Army Natick Soldier Research, Development and Engineering Center
OT&E	Operational Test and Evaluation
PAM	Pamphlet
PD	Purchase Description
PHS	US Public Health Service
PMCS	preventive maintenance checks and services
POL	petroleum, oils, and lubricants
PPE	personal protective equipment
PS	Performance Specification
psi	pounds per square inch
PVT	Production Verification Test
RA	Risk Assessment
RADHAZ	Radiation Hazard
RB-M	response boat - medium
RFTS	Request for Test Services
RH	relative humidity
RHIB	rigid hull inflatable boat
RITA	Repository Information and Test Analysis
RPG	rocket-propelled grenade
rpm	revolutions per minute
RPSTL	Repair Parts & Special Tools List
RRDF	Roll-on/Roll-off Discharge Facility
RS&V	road shock and vibration

APPENDIX D. ABBREVIATIONS.

SAR	Safety Assessment Report
SC	Safety Confirmation
SDDCTEA	Military Surface Deployment and Distribution Command - Transportation Engineering Agency
SEP	System Evaluation Plan
SN	serial number
SOLAS	safety of life at sea
SOUM	Safety-of-Use Message
SOW	Statement of Work
SR	Safety Release
SSP	system support package
STBD	starboard
TACOM-LCMC	US Army Tank-Automotive Command Life Cycle Management Command
T&E WIPT	Test & Evaluation Working-level Product Team
TIIN	test item identification number
TIR	Test Incident Report
TM	Technical Manual
TNT	trinitrotoluene
TOP	Test Operations Procedure
TSARC	Test Schedule and Review Committee
TSP	Test Support Package
TTPs	tactics, techniques, and procedures
UNDEX	Underwater Explosion Facility
VCG	Vertical Center of Gravity
VDLS	VISION Digital Library System
VEPA	Vehicle Endurance Performance Analyzer
VISION	Versatile Information Systems Integrated On-Line
VMOM	vertical moment

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APPENDIX F. APPROVAL AUTHORITY.

CSTE-TM   5 November 2012

MEMORANDUM FOR

Commanders, All Test Centers
Technical Directors, All Test Centers
Directors, US Army Evaluation Center
US Army Operational Test Command

SUBJECT: Test Operations Procedure (TOP) 09-2-251A, Waterway Equipment - Boat, Barge, Motor, Approved for Publication

1. TOP 09-2-251A, Waterway Equipment - Boat, Barge, Motor, has been reviewed by the US Army Test and Evaluation Command (ATEC) Test Centers, the US Army Operational Test Command, and the US Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency. The scope of the document is as follows:

This TOP provides guidance for preparing test plans and conducting test programs to evaluate waterway equipment performance and operational characteristics and identifies required facilities and equipment. This TOP is applicable to barges; lighters; and passenger, cargo, landing, assault, picket, patrol, tug, tow, and special-purpose boats.

2. This document is approved for publication and has been posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at https://vdls.atc.army.mil/.

3. Comments, suggestions, or questions on this document should be addressed to US Army Test and Evaluation Command (CSTE-TM), 2202 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil.

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Range Infrastructure Division (CSTE-TM), US Army Test and Evaluation Command, 2202 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: Support Equipment Division (TEDT-AT-WFE), US Army Aberdeen Test Center. Additional copies can be requested through the following website: http://itops.dtc.army.mil/RequestForDocuments.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.